Ecosystems
(Level 6)

Teacher's Guide

Chester A. Lawson
Robert Knott
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Preface: From SCIS to SCIIS

Over the past twenty years almost a hundred curriculum projects—the majority in science—germinated on the educational landscape. Some withered, some bloomed, and some not only thrived but went on to propagate successful offspring. Among the latter has been the Science Curriculum Improvement Study (SCIS), which grew out of Robert Karplus's early studies of elementary school children and science learning in the 1960s. Funded by the National Science Foundation, and eventually housed at the Lawrence Hall of Science, University of California at Berkeley, the SCIS program became one of several curriculum projects that have markedly changed the direction of elementary science education in the 1970s. After extensive testing with thousands of students and teachers, the first commercial edition of SCIS was published by Rand McNally in 1970–72.

The educational impact and acceptance of SCIS was rapid and widespread. The insights, commitment, and enthusiasm of the SCIS developers were passed on to the teachers using the program—directly and through workshops, in-service training, and visitation programs at the Lawrence Hall. These efforts were significantly reinforced by the publisher, who sponsored additional programs for teachers, set up information and awareness centers, provided consultants, and serviced thousands of schools with its representatives. In less than three years SCIS clearly established itself as a program to emulate. No other available materials provided science educators with so much flexibility in subject matter, classroom materials, and teaching strategy, within a clearly defined conceptual framework. No other program so explicitly set scientific literacy as its overall goal for children—and then earned the documentation (mostly from independent sources) to show achievement of that goal. No other program introduced children to the life sciences by bringing live organisms into the elementary classroom for direct observation and study. And no other program that focused on *doing,* rather than reading about, science was more widely adopted and used in the schools.

For these reasons, SCIS has been a challenging program and, at the same time, one that has been a pleasure to teach and to learn from. The challenge lay in the need for the developers, the publisher, and teachers to give something more in terms of time and effort, and to effectively create, deliver, and present to students the concepts and activities embodied in SCIS. For example, one of the salient and essential features of the program is the presence of live organisms in the classroom; the culturing, scheduling, procurement, use, care, and maintenance of selected plants and animals, no matter how hardy, required a commitment over and above that needed in a "read-about" science program.

On the other hand, that SCIS has been a pleasure to teach is a judgment that comes from thousands of educators and children who have used it. An overwhelming majority have told the publisher and the authors that student interest, enthusiasm, and achievement have been markedly increased in their classes—and not only in terms of science. Language and communication skills have improved, as supported by research. Ability and willingness to observe, measure, collect data, organize information, reason, interpret, and weigh evidence have been characteristic of SCIS learners. Anticipating and then witnessing these outcomes in the classroom helps to make teaching what it at least occasionally needs to be—a joyful experience.

During the 1975–76 school year Rand McNally invited approximately 500 elementary specialists and teachers using SCIS in a wide variety of locations and educational environments to review the materials and comment critically from their own experiences. They did so in person and in writing, and the resulting feedback has provided a basis for thorough revision by members of the original SCIS author team. Working together, the authors and the publisher began developing the new program you now have in hand. The task encompassed far more than merely remodeling the existing activities, books, and equipment. New activities, concepts, themes, learning components, design, packaging, sources of supply, delivery systems, and services to support teachers — these and other features of the new program were scrutinized and tested in schools or laboratories, and measured against the expressed needs of the schools.

The end result is the Rand McNally SCIIS program.

We are pleased with it. We are confident that it will provide you and your students with even greater opportunities for learning and enjoyment in science—and in ways related to other disciplines—than did its predecessor. And we want to hear from you about your experiences with it (see the Evaluation Response Form, drawer 1, in the kit).

Finally, our thanks to the many teachers, parents, and children who voluntarily gave us the benefit of their comments. We would like the reader to join them—as a user and as a friendly critic—in the ongoing task of improving science education, with SCIIS.

A note about the title and logo

We seem to be nearing a time when the supply of possible acronyms for educational programs, projects, and organizations will be exhausted. Rather than contribute to a further drain on the supply, we thought it singularly appropriate to retain much of what "SCIS" has been—in name as well as in substance. We saw the task as one of improving SCIS *from within* a conceptual and physical framework that had already proven itself in the classroom, rather than simply adding on from outside or giving the impression that we were starting from scratch again. Hence, SCIS became SCIIS, with another I inserted. And something resembling the original "snowflake" survives in the logo.

For the literal-minded, the new I may serve to represent further improvement, or more innovation, or (with its partner) a two (II). Thinking about and debating such fine points provided hours of recreation for editors, advertising staff, and project management. We would prefer that you call the program "Rand McNally SCIIS" to avoid confusion with the earlier SCIS or with other products now using a similar name.

For the Authors—
Herbert D. Thier

For Rand McNally—
William Miller

August, 1977

An Introduction to SCIIS

The Conceptual Framework

Diversity and change—in the landscape, in cloud formations, at the zoo, in a jar of sugar water forming rock candy—attract children's attention and awaken their interest. Curious about their surroundings, children naturally seek to describe and sort the diverse animals, plants, and nonliving materials they discover. In this respect they resemble scientists, who try to understand the basic conditions governing change.

THE GOAL: SCIENTIFIC LITERACY

Through investigation, scientists' understanding of nature advances from simple hypotheses to complex theories. Similarly, children's thinking advances from the concrete to the abstract as they accumulate experiences and ideas. They develop more effective techniques for observing and testing nature. In other words *they become scientifically literate*.

Scientific literacy derives from basic knowledge, investigative experience, and curiosity. In the SCIIS program, these three factors are integrated, balanced, and developed through the children's involvement with basic scientific concepts, process-oriented concepts, and challenging problems for investigation.

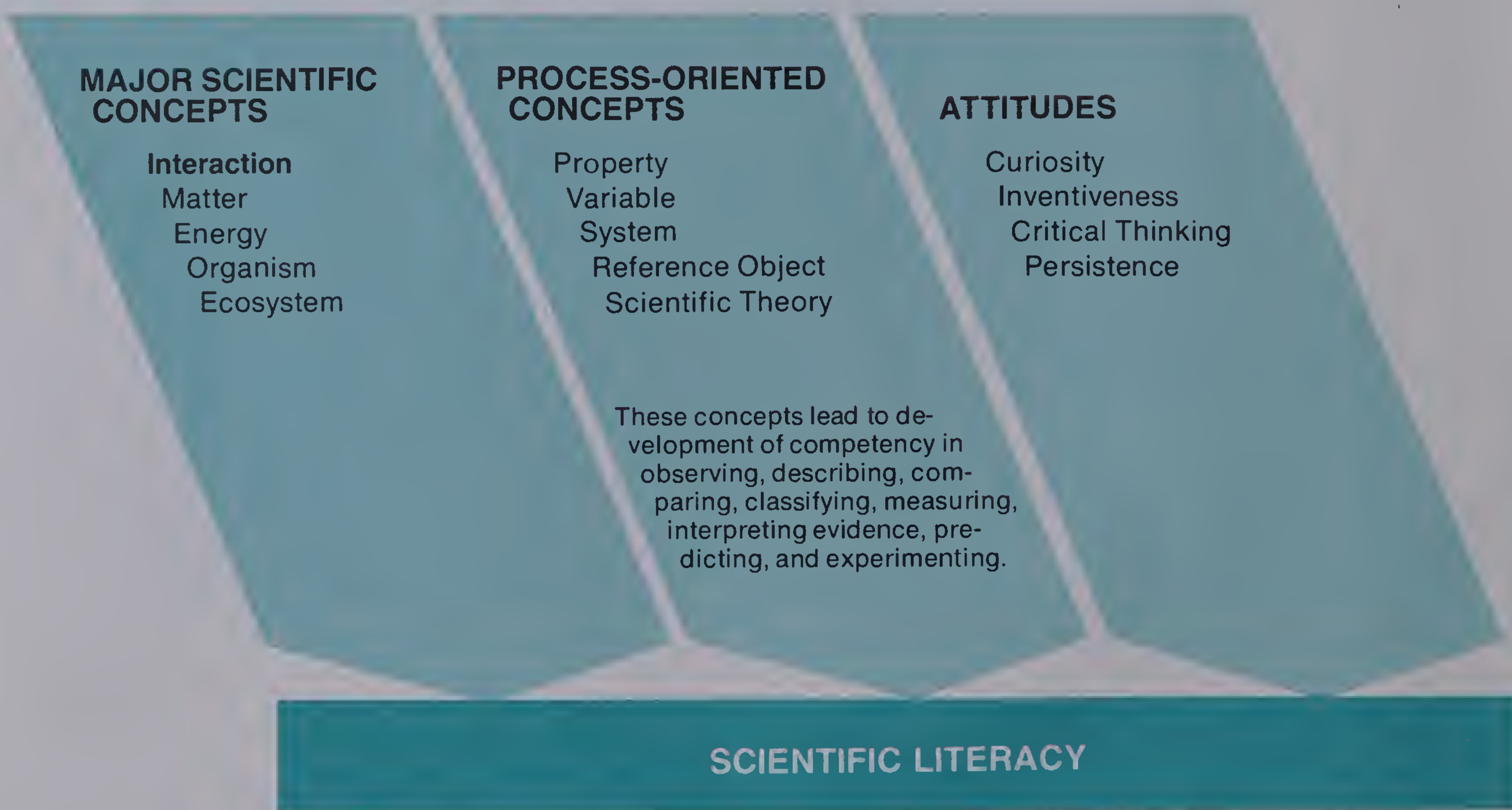
CONCEPTS, PROCESSES, AND ATTITUDES

Educators frequently distinguish among content learning, process development, and attitude formation when they describe an educational program or evaluate its outcomes. The SCIIS program combines these three factors into an integrated whole, matching the way children learn. Children are introduced to scientific content through firsthand experiences—with magnets, gears, fish, crickets, and a wide range of other living and nonliving materials.

In the course of their investigations, children engage in observation, measurement, interpretation, prediction, and other processes essential for the development of scientific literacy.

Finally, the SCIIS program helps children form positive attitudes toward science as they explore phe-

SCIIS CONCEPTUAL FRAMEWORK



nomena. Using their own ideas and preferences, children learn to cope confidently with new and unexpected findings by sifting evidence and forming conclusions—thus removing the "magic" from science.

Major Scientific Concepts *Interaction.* The concept of *interaction* is central to modern science—and therefore also to the SCIIS program. This concept embodies the scientific view that changes in nature take place because objects interact in reproducible ways when conditions are controlled. In the scientific view, changes do not occur because they are preordained or because a "spirit" or other power within objects influences them capriciously.

When objects or organisms do something to one another that brings about a change, we say that an interaction has occurred. When you clap your hands, they interact with one another and the air. The observed changes, the sensation in your palms, and the sudden sound are evidence of interaction.

Children can easily observe and use such evidence. They can watch a guppy eat a daphnia, hear bubbles when seltzer tablets dissolve, spin a compass pointer with a magnet, and detect the odor of decomposing organic materials. As they advance from dependence on concrete experiences to the ability to think abstractly, children can identify the conditions under which interactions occur and predict their outcomes.

In SCIIS, four major scientific concepts elaborate the interaction theme—*matter*, *energy*, *organism*, and *ecosystem*. Children's experiences and investigations in the six units that make up the physical/earth science sequence are based on matter and energy.

Organism and ecosystem provide the framework for the six units in the life/earth science sequence. Additional concepts are described in the appropriate Teacher's Guides.

Matter. Matter, or material, is introduced in the SCIIS program through the solids, liquids, and gases in the environment. These interact with human sense organs and with each other. Material objects can be described and recognized by their color, shape, weight, texture, and other properties. As children investigate changes in objects in the SCIIS physical/earth science sequence, they become aware of the diversity of interacting objects and their properties.

Energy. Energy is the inherent ability of a system to bring about changes in itself or in the state of its surroundings. Some familiar energy sources are the natural gas used to heat a kettle of water, the horse used to pull a plow, the unwinding spring that operates a clock, and the discharging battery in a pocket radio. The complement of an energy source is an energy receiver, such as the football kicked by a player or the ice cube placed in warm water. The interaction between energy source and receiver results in energy transfer.

Organism. An organism is an entire living individual—plant or animal. It is composed of matter, and it uses the energy from its food to develop, grow, and be active. The organism concept represents a fusion of the matter and energy concepts, but it is much broader than the sum of its parts. An essential factor is the organization of matter into cells and other structures that assure continuity of life from generation to generation.

Ecosystem. Awareness of the interactions between organisms and the environment leads to the ecosystem concept. As children observe living plants and animals in the classroom or out-of-doors, they notice the amazing diversity of organisms and their life cycles. They observe how plants and animals interact with one another and with the soil, atmosphere, and sunlight in the complex network of relationships that constitute an ecosystem.

Think of a forest as an example. A forest is more than an assemblage of trees. Living in the shade of trees are shrubs, vines, herbs, ferns, mosses, and toadstools. Dependent upon these plants and living among them are insects, birds, mammals, reptiles, and amphibians. The animals depend on plants for food, shelter, and other needs. The plants use sunlight, carbon dioxide, water, and minerals to make food that sustains themselves and other organisms in the forest.

Process-Oriented Concepts. By defining and emphasizing specific concepts, SCIIS permits teachers and pupils to concentrate on the objectives of the program. Five process-oriented concepts—*property* (or characteristic), *variable*, *system*, *reference object*, and *scientific theory*—underlie and are essential for development of competency in the processes of observing, describing, comparing, classifying, measuring, interpreting evidence, predicting, and experimenting.

Property. We have already referred to the properties by which an object may be described or recognized. A property is any quality that enables you to describe, compare, or classify objects. Color, size, shape, texture, and scent are properties of a blossoming plant; color, density, and hardness are properties of a mineral specimen; and size, color, and style are properties of a suit of clothes.

Properties also enable you to describe concepts. For example, duration is a property of a time interval; accuracy is a property of a carefully-made measurement; and the term climate (hot, cold, temperate) summarizes the properties of weather in a specific region.

Variable. Properties and conditions that differ from one experiment to another are important in scientific

work, and they have been given a special name—variables. Examples are the temperature of water being warmed by the sun, the amount of fertilizer added to a potted ivy plant, the length of time a flashlight battery has been used, and the number of crickets feeding on a particular patch of grass.

System. System is a word that has entered everyone's vocabulary. We deal with the nervous system, communications systems, electronic systems, and systems analysis. In all of these a system is a whole made up of related parts. Earth and its moon form a system of two closely interacting bodies in space. A seed, moist soil in which it is planted, and air form a system. The system concept reflects the fact that objects and organisms do not function in isolation but exist in a context of interaction with other objects or organisms.

When one system is part of another system, it is called a *subsystem.* The earth, including its atmosphere, plants, and animals, is a subsystem of the earth-moon system. The seed, with its embryo, seed coat, and stored food, is a subsystem of the seed-soil-air system.

The terms object, subsystem, and system allow us to use three levels for grouping the elements that attract our attention in an event. We shall use the word "object" for individual pieces of matter, "subsystem" for intermediate groups of objects, and "system" for the largest collection under consideration.

We have concentrated on "closed" systems in the SCIIS physical/earth science sequence. A closed system is defined by the matter of which it is composed. Whenever matter is added to, removed from, or replaced by, other matter, the original system becomes a new system. When nothing is added or removed, a system retains its identity even though it may change in form or appearance.

Sometimes (especially in the life sciences) scientists find it useful to work with "open" systems, which are defined by the matter occupying a certain region of space. The air space within a terrarium is an example. In an open system there may be changes of matter without changes in identity—as when water vapor, carbon dioxide, and oxygen enter and leave the air even though the terrarium is covered. The ecosystems children investigate in Level 6 are examples of open systems. Children who continue to study science may learn to distinguish between open and closed systems when that distinction becomes important.

Reference object. The fourth process-oriented concept, reference object, helps children overcome the limitations of describing position and motion only from their own point of view. Space exploration has shown that we can no longer think exclusively in terms of up-down and north-south as defined on the earth. For young children—who at first relate objects only to themselves—the use of external reference objects is a challenge.

In SCIIS, the basic concept is simple: Position and motion of objects can be described only with reference to other objects, including (possibly) the body of the observer. When you say, "Meet me at the north end of the picnic area," you describe the location of the meeting place relative to the picnic area. In the example, the picnic area serves as reference object and the compass direction serves as reference direction. When you say, "The main entrance to the museum is to your left," you are using the listener's body as reference object.

The child who can take into account several reference objects and reference directions overcomes a spatially self-centered viewpoint. The concept of the earth as a sphere in space can be understood only in relation to a reference object not located on the earth itself; therefore an understanding of reference objects is fundamental to further work in earth and space sciences.

Scientific theory. An example of a scientific theory is the ray theory of light, which holds that light consists of rays propagating from a lamp or other light source to your eye or an illuminated object.

An everyday example of theory-building can be derived from a look at a common pay phone. How does the coin turn on the phone connection? One might imagine that the coin falls on and depresses a small platform, thereby closing a switch. What is your theory of how the coin turns on the telephone? Keep in mind that many phones work with a dime but not with a nickel, or with two dimes but not with three nickels, even though a nickel is heavier than a dime.

Scientific theories provide explanations for natural phenomena such as light, photosynthesis, weather, heredity, chemical combination, or the solar system. A theory usually postulates certain unseen relationships or objects, such as light rays emanating from a lamp, the platform in a telephone, or atoms in a material substance. Theories also lead to predictions and new discoveries about the events being investigated. If the predictions are not borne out, a theory may be discarded. By using scientific theories, children can relate present observations to previous and subsequent experiences with similar events.

Structure and Content

The SCIIS program consists of thirteen learning units in science for children at preschool, kindergarten, and elementary school levels. The introductory unit, *Beginnings,* leads into two six-unit sequences—the physical/earth science sequence and the life/earth science sequence.

The two sequences are complementary in that either of the two units for any one level may be used first. For example, at Level 1 you may use *Material Objects* in the fall and *Organisms* in the spring, or vice versa. This flexibility permits switching of units between two classes at midyear. (Supplementary and alternate packages of materials are available for schools wishing to switch units, to share unit kits among two or more classes, or to supply exceptionally small or large classes.)

The physical/earth science sequence guides children through carefully selected investigations of the physical world. In the same way, the life/earth science sequence focuses attention on the biological world. Both sequences include treatment of some topics relating to the earth sciences—shadow astronomy, map coordinates, water and mineral cycles, and climatic factors are examples.

SYNOPSES OF THE UNITS

Concepts and processes developed and emphasized throughout the SCIIS program have been described in the preceding "Conceptual Framework." The following summaries list the concepts and processes most important within each unit.

Level K *Beginnings*
Concepts and processes emphasized in this unit: color, shape, texture, odor, sound, size, quantity, position, organism.

The *Beginnings* unit for kindergarten and early childhood education offers a wide variety of activities and experiences in both life and physical sciences. Most of the activities are designed for use in small-group learning situations. Children learn to observe, discriminate, and describe, using objects and organisms in the classroom and outdoors. These early experiences help them develop language and participation skills and contribute to their growing understanding of science. The *Beginnings* unit leads into the physical/earth science and life/earth science sequences.

SCIIS STRUCTURE AND SEQUENCE OF UNITS

Level	Physical/Earth Science Sequence	Life/Earth Science Sequence
K	BEGINNINGS	BEGINNINGS
1	MATERIAL OBJECTS	ORGANISMS
2	INTERACTION AND SYSTEMS	LIFE CYCLES
3	SUBSYSTEMS AND VARIABLES	POPULATIONS
4	RELATIVE POSITION AND MOTION	ENVIRONMENTS
5	ENERGY SOURCES	COMMUNITIES
6	SCIENTIFIC THEORIES	ECOSYSTEMS

Physical/Earth Science Sequence

Level 1 *Material Objects*
Concepts and processes emphasized in this unit: object, property, material, serial ordering, evidence.

The children handle, observe, and describe objects. They learn that objects are composed of materials and have properties by which the objects can be discriminated; that some objects are solids, while others are liquids or gases; that objects can change; and that there are ways to recognize evidence of change. Property comparison leads to the concept of serial ordering. As the children investigate the properties of various materials, they realize that the same substance can exist in more than one form, and they gain an awareness of the principle of conservation of matter.

Level 2 *Interaction and Systems*
Concepts and processes emphasized in this unit: interaction, system, evidence of interaction, interaction at a distance.

The concept of interaction is introduced, as well as the concept that related objects or parts comprise a system. Students examine a variety of interactions, some of which are directly observable, others less apparent. The evidence that an interaction has taken place comes from the observed change in the system. The children investigate gear/pulley systems, chemical systems, magnetic systems, and electric circuits to observe and interpret evidence of interaction.

Level 3 *Subsystems and Variables*
Concepts and processes emphasized in this unit: subsystem, solution, evaporation, histogram, and variable.

The subsystem concept is introduced to give the children a grouping of objects intermediate between a single object and an entire system. The children's work with solid and liquid materials extends their understanding of the subsystem concept. They learn that filtering will separate an undissolved solid from a liquid, but that solids dissolved in solutions must be identified by the residue that remains after the liquid evaporates. Histograms are used to record and interpret data collected by the students. The variable concept helps them to identify and investigate factors influencing their experiments.

Level 4 *Relative Position and Motion*
Concepts and processes emphasized in this unit: reference object, relative position, relative motion, polar coordinates, rectangular coordinates.

The ideas and techniques developed in this unit are related to concepts of earth and space science. Students find that descriptions of position and motion are meaningful only if reference to objects and coordinate systems—both polar and rectangular—are included in the descriptions. An artificial observer, Mr. O, serves the children as an introductory reference object. They see that reference to different objects and coordinate systems leads to different descriptions of position and motion. Children also learn to use a variety of reference frames to describe both the position and the motion of objects in their everyday environment.

Level 5 *Energy Sources*
Concepts and processes emphasized in this unit: energy source, energy receiver, energy transfer, energy chain.

The concepts of energy source, energy transfer, and energy receiver constitute the core of the unit and are illustrated with experiments exploring mechanical and thermal systems. The importance of solar energy to meet some of our needs is emphasized in this unit. The children's descriptions of the amounts of energy transferred from a source to a receiver help to prepare them for understanding and applying the principle of conservation of energy.

Level 6 *Scientific Theories*
Concepts and processes emphasized in this unit: scientific theory, color, magnetic field, electricity, light ray.

The extended investigations and formulation of scientific theories in this unit conclude the physical/earth science sequence. In *Scientific Theories*, children create their own theories to explain their observations of colored light, magnetic interactions, electric circuits, and simple ray optics. Investigations provide opportunities for students to think of theories to explain the operation of systems of interacting objects and to devise tests to distinguish among alternate proposals. In doing so, they gain a deeper understanding of how scientists work.

Life/Earth Science Sequence

Level 1 *Organisms*
Concepts and processes emphasized in this unit: organism, birth, death, habitat, food chain, decay.

The stage is set for the unit as children plant seeds, watch the growth of the seedlings, and experiment to see how external conditions affect growth. Their observations are extended to a model ecosystem—an aquarium. They observe changes that occur in the aquarium, including the growth of plants and animals, animals feeding on plants, animals eating other animals, birth, death, and decay. Experiences with classroom plants and aquariums give children a general introduction to the overall theme of the life/earth science units: the interaction of organisms with their environments.

Level 2 *Life Cycles*

Concepts and processes emphasized in this unit: growth, development, life cycle, genetic identity, plant and animal, metamorphosis.

Attention is shifted from the ecosystem as a whole to some of its important parts—individual plants and animals. Through experiences with living, dead, and nonliving objects, the children have an opportunity to learn these classifications of objects around them. Living and dead organisms are further subdivided into plants and animals. By observing live, growing, developing, reproducing plants and animals, the children become aware of the fact that living objects have life cycles.

Level 3 *Populations*

Concepts and processes emphasized in this unit: population, plant-eater, food web, biotic potential, animal-eater, plant-animal-eater, predator-prey.

The children learn that the individual plants and animals they observed in previous units live as groups in nature. They build, maintain, and observe terrariums and aquariums, and they investigate the interactions of populations—food webs, for example—in each system. The concept of biotic potential can be inferred after the pupils are asked to imagine, with the help of prepared charts, what could happen in a population if reproduction continued without any deaths.

Level 4 *Environments*

Concepts and processes emphasized in this unit: environment, environmental factors, biotic, abiotic, range, optimum.

The environment of an organism consists of biotic factors, which include all the other plants and animals living in the same area; it also includes abiotic factors, such as light, temperature, air, water, and soil. The children experiment with both plants and animals to discover the effects of changing various factors, to establish a range of conditions for testing each factor, and to find the optimum part of a range for each organism. On the basis of data collected from these experiments, students build terrariums with suitable environments for the organisms. They discuss and plan a human environment that includes other organisms on which humans depend.

Level 5 *Communities*

Concepts and processes emphasized in this unit: pyramid of numbers, raw materials, reproduction, community, producers, consumers, decomposers, photosynthesis, food transfer, competitors.

In *Communities*, emphasis is placed upon interactions among different populations of organisms, the most important of which concerns food. Students examine the interdependent relationships among plants (as producers), animals (as consumers), and microorganisms (as decomposers). The children investigate the capacity of green plants to produce food. They build terrariums containing plants, crickets, and salamanders, and observe the food-chain relationships. And they observe the results of decomposition after burying dead crickets in moist sand.

Level 6 *Ecosystems*

Concepts and processes emphasized in this unit: ecosystem, water cycle, oxygen-carbon dioxide cycle, pollution, food-mineral cycle.

The cycle concept is introduced by means of experiments with evaporation and condensation of water that lead to an understanding of the water cycle. Students learn that the ecosystem is maintained by the intake of energy from the sun and by the continuous recycling of materials between organisms and the environment that surrounds them. Ecosystems are seen to include all the concepts in the life/earth science sequence as children see the pattern of ecosystems in North America and identify their own ecosystem. Changes in the balance in natural ecosystems, including those caused by pollution, are studied.

Helping Children Learn with SCIIS

SCIIS is a science program based on direct experience. It is intended to affect the ways children think and reason. In addition it is expected to influence how they will reason and make decisions about problems when they become teenagers and adults. Such thinking and decision-making may well determine the individual's responses to a wide variety of personal and societal issues: Should I smoke or not? Should I vote for or against the use of coal as an energy source in my community? In both cases the intelligent person must be able to understand the variables, critically assess advertising campaigns and the statements of special interest groups, and separate emotional appeals from real evidence.

SCIIS fosters this kind of thinking and decision-making, which is quite different from the kind of skill-oriented learning that takes up a large part of the child's elementary school experience.

The need for skill learning. Children need to learn the skill aspects of language, writing, and arithmetic. Your role in teaching these skills is that of an instructor (one who imparts information) who knows precisely what is to be learned and "gets it across" effectively. The importance of such instruction cannot be questioned, because the skills are basic to participation in society.

Development of reasoning. The individual, however, deserves and needs a great deal more than skill learning to participate meaningfully in a democratic society. The ability to use one's own experiences as a foundation for understanding, interpretation, and decision-making in life is essential. It is this ability to observe, collect evidence, analyze, and use the information obtained from one's experiences that is emphasized in the SCIIS program.

For these reasons your role when teaching such experience-based science is that of a helper and fellow-investigator, rather than only that of an authority or imparter of knowledge. The sections that follow describe the components and organization of SCIIS, and how you can use the program to help children learn both science and the approach to decision-making inherent in science.

PROGRAM COMPONENTS

Teacher's Guide. Central to each unit of the SCIIS program is the Teacher's Guide. It shows how the unit is broken into parts and chapters. Specific learning objectives are listed at the beginning of each Part. The rationale underlying the Part is explained under the heading "Background Information." Next is an "Overview" of the chapters that make up the Part. Any suggestions for organizing time and equipment are provided in notes titled "Planning Ahead" and "Getting Ready."

Each chapter begins with a color panel containing a chapter synopsis, the time suggested for covering the chapter, and a list of materials needed for the activities. Major headings within a chapter are "Advance Preparation," "Teaching Suggestions," "Optional Activities," and "Extending Your Experience (EYE) cards." If background information specific to the chapter is needed, it is included just before "Advance Preparation."

At the end of each Part, notices tell you which EYE cards (in the kit) may now be made available to the children and refer you to the appropriate evaluation activity at the back of the Guide.

Following the last chapter of the Guide you will find an "Evaluation" section, a glossary of important terms, and a page explaining design and use of the equipment and materials kit. The life/earth science units also contain an appendix on care of organisms (following the glossary) and an overall schedule of activities.

Scheduling. One activity may extend beyond a single science session, or several activities may be included in one session. The "Suggested time" for working through a chapter is *only* a suggestion; adapt your schedule to allow for special student interest or for greater use of a chapter or activity that is particularly appropriate in your locale.

Teaching suggestions. Under this heading you will find all the activities intended for use by the whole class. Most activities are carried out by individuals or teams working with the necessary materials to collect data or other evidence. While this happens, you are free to move around the classroom to help those who have problems.

Once the data are collected, conduct a discussion of the results, and encourage children to draw conclusions about the data. The work with the equipment and materials and the subsequent discussions are fundamental to the reasoning and decision-making processes SCIIS is designed to foster.

A willingness to improvise and depart from the teaching suggestions will better enable you to meet your pupils' needs. Students may ask questions not anticipated in the Guide or that do not lead in the direction you planned. When this happens, permit the pleasure of a "side trip" by encouraging interested individuals or small groups to investigate independently and report back to the class.

Optional activities. In many chapters individual and small-group needs and interests are met by the "Optional Activities" section. These expand upon topics brought up in the chapter or help in reviewing concepts studied earlier. You may use optional activities to:

- extend the main activities if a child raises a related question
- emphasize one topic for the entire class
- expand the unit extensively if your class is more mature than usual for this level

Optional activities make use of materials provided in the program, common household supplies, or other readily available items. We hope you will include at least a few of these activities in your program, but we do not expect you to use all of them.

Evaluation and feedback. Feedback is information that comes to a person in response to something the person did. As a teacher, you are collecting feedback from your pupils most of the time. An answer to a question yields feedback. So does a child who looks out the window during your demonstration. Informal feedback is an important way to evaluate the progress of your class. In this Guide, we will try to alert you to feedback situations in which children's responses are likely to influence your teaching plans.

In addition to the feedback suggestions included in each chapter, we have prepared an evaluation section that uses a more formal approach to evaluating your students' learning. In general, there is one evaluation activity for each Part of the unit.

Teacher's glossary. Scientific terms and concepts used in the unit are defined in the glossary. The definitions are appropriate for reference during discussions or review and are not intended to be technically exhaustive. We do *not* recommend that you use the glossary to have children memorize formal definitions of terms and concepts.

Equipment and materials kit. Each SCIIS kit includes all necessary materials for the unit except live organisms, common items such as pencils and paper, and perishable items such as batteries.

Each chapter in the Teacher's Guide begins with a list of materials needed and their location in the kit. Starred (*) items in the list are to be provided by the teacher. "Design and Use of the Kit" (page 114) and labels on each kit drawer also indicate placement of items.

Live organisms. The life/earth science units require that you order shipments of live organisms (already paid for), prepare suitable habitats, and allow time for growth and development of the organisms. The life/earth science kits contain the forms for ordering SCIIS organisms. At the back of the Guide, the "SCIIS Plants and Animals" appendix and the "Schedule of Activities" will help you plan and carry out all work with live organisms.

Student manual. The student manual has two major functions: It helps guide the children through their experiences with the equipment and materials, and it provides a place for the individual to record observations, findings, or measurements. During many activities the children record information about experiments in their manuals. This may provide the basis for later discussions.

Encourage children to make entries independently, even though their reports may disagree with those of classmates or with what you consider to be "correct." Some children may change their responses; let them cross out the first entry and add the new one. In this way, their original record is preserved and may be compared with later observations. Records in the manual should be informative, but they need not be perfect.

In addition to organizing the children's work and record-keeping, the manual contains some problems to be solved either individually or in class discussion. But most of the manual is directly related to the children's experiences with the equipment and materials. This relationship makes the SCIIS student manual different from the typical elementary "workbook."

Collect the manuals periodically to review the children's record-keeping and problem-solving abilities. We suggest you refrain from writing in the manuals, either to commend or to correct mistakes. If you find repeated errors in reasoning or data interpretation, arrange for a conference with the child.

Extending Your Experience cards. These cards (two duplicate sets with a display box) are provided primarily to encourage development of individual interests. We have controlled vocabulary on the cards, so that most children should be able to read them unassisted. The illustrations are intended to help the children work independently. Make each card available — by adding it to those in the display box — at the time its use is recommended in the Guide.

The cards may be used in a variety of ways, ranging from totally independent work to a more controlled situation in which you or an aide suggest and supervise a pupil's use of a card.

Some cards may be used for review or remedial purposes. Some may be assigned to provide additional experiences for children new to the SCIIS program. The cards to be used with review chapters at the beginning of the Guide will prove useful for these purposes.

Encourage children to report orally, in writing, or through picture displays after they complete work with a card. They can report to you, to their team, or

to the class as a whole. In this way, children can benefit from the opportunities for language development inherent in the use of the cards.

As children express interest in topics not covered by the cards provided, you might help them develop new cards that relate to their specific interests.

THE LEARNER IN SCIIS

The SCIIS program is intended for children between the ages of 5 and 12–13 years. Therefore, the teaching approach needs to be matched to the learning styles, interests, and capabilities of children of these ages. Research on the learning of young children has led us to recognize a three-stage development in the way children learn. These stages are explained more fully in the following sections.

Exploration. Children learn about something through their own spontaneous handling and experimenting with objects to see what happens. Thus in SCIIS children first explore materials with minimal guidance in the form of instruction or specific questions. The materials have been carefully chosen to provide a background for certain questions the children have not asked before.

You can help exploratory activity by asking questions and making comments that encourage further involvement. An individual's creative use of materials can be pointed out as a means of providing others with new ideas. During exploration activities you have the opportunity to observe the children and draw conclusions about their existing ideas and understandings. This evaluation can be the basis for further planning and instruction.

Invention. Spontaneous learning is limited by preconceptions. After exploration, a child needs new concepts to interpret observations. Since few children can phrase new concepts by themselves, you will have to provide definitions and terms as new concepts arise. This constitutes the "invention."

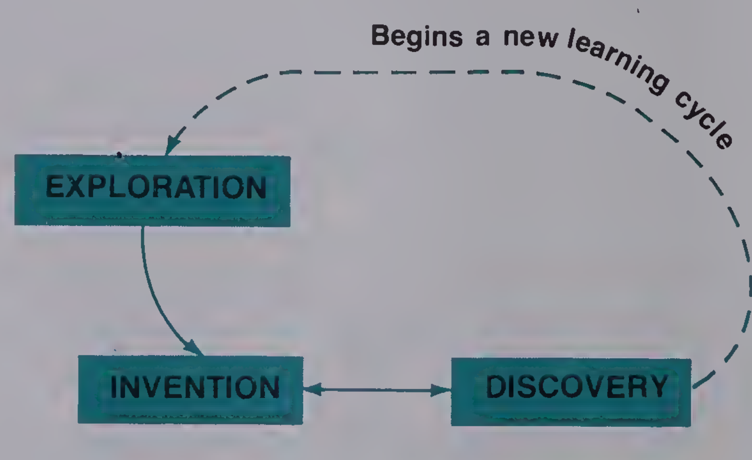
During an invention lesson, be clear and explicit when you give a definition, repeating it several times if necessary. To give the children opportunities to use a concept, encourage them to look for examples that illustrate the new idea. When they report such examples — immediately or during later discovery activities — you gain feedback about their understanding of the concept.

Keep in mind that the "invention" or introduction of a new concept is just the start of an experiential process for a child. Knowledge, understanding, and eventual ability to use the concept in daily life will come from experiences the child has during and after the discovery activities.

Discovery. We use "discovery" to describe those activities in which a child finds a new application of a concept through experience. You may plan a variety of situations leading to discovery, or you may depend on a child's own experiences to furnish these applications. Discovery activities strengthen the original concept and enlarge its meaning. Mastery and retention of concepts are aided by practice and repeated application in the variety of situations provided in the activities.

During discovery sessions, your role is to assist the children so they can effectively work with materials and see how concepts apply. In this stage they are actively involved, and you can spend your time with individuals or small groups to observe their work and to ask questions that spur further investigation. Where necessary, reintroduce the concept previously explained or review earlier ones.

The learning cycle. Exploration/invention/discovery are stages in a learning *cycle* because each stage can always lead to another. Exploratory sessions frequently include discovery activities for prior concepts while creating a need for your introduction of the new concept. Invention sessions frequently lead to questions best answered by giving children opportunities to work on their own, and thus to discover applications of the new concept. Discovery activities can provide opportunities to reintroduce concepts "invented" earlier and they can permit children to explore the next concept. Diagrammatically we can represent the learning cycle this way—



The Learning Cycle

At the beginning of the "Teaching Suggestions" for each chapter we have indicated the stage(s) of the learning cycle emphasized in the activities that follow.

Implementing learning stages. Exploration, invention, and discovery can be implemented with varying degrees of direction. A more structured approach is illustrated when an entire session is used for introduction of a concept in a presentation to the whole

class. This should be preceded by exploratory activities and followed by discovery activities of a more personalized nature.

Using a less formal technique, you may introduce a new concept to individual children during their exploratory or discovery activities. To do so, join one child or a small group and use the child's own equipment to illustrate the concept. This method may be used effectively during the review chapters at the beginning of each unit after Level 1. Regardless of the approach you choose, you may have to explain and illustrate a new concept repeatedly to individual children during discovery activities.

TEACHING APPROACHES AND STRATEGIES

Organizing the classroom. Teachers who have contributed to the development of the SCIIS program have found that many responsibilities for preparation and cleanup can be shared by pupils. The following suggestions will help your class enjoy successful laboratory sessions:

1. In many SCIIS activities, children work in small teams — usually pairs. Plan teams carefully, to insure maximum cooperation.
2. For ease in managing supplies and cleanup, assign two or three teams to a work area — a table, or several desks of equal height pushed together. Such a group can share one water container, one waste pail, soil, and other shareable items. They also can exchange ideas about the activity. One member of each group may serve as a laboratory aide.
3. Ask your aides to assemble supplies for each team or group and to help you in passing out equipment. Or you can have them assist you in placing sets of equipment at distribution stations around the room. You may want to post signs at stations to identify equipment and indicate how much is to be used by each team.
4. Invite parents or other community members to assist you as aides in the class. Invite individuals with scientific backgrounds or interests to present special activities relating to activities under way, or to supervise a team working on a special project.

Discussions. Conversation among children or between teacher and children is an important part of the learning process. While participating in experiments, children spontaneously exchange observations and ideas with one another. During an invention session, you illustrate and explain a new concept. When gathering feedback, you may address a question to a particular child.

On other occasions, we suggest discussions in which the children report on their experimental results, compare observations, and sometimes challenge one another's findings. Many children should participate in these discussions, and you, the teacher, should avoid controlling the topic or the pace. Encourage the children to comment to one another, without calling on specific individuals to recite in turn. Grouping them to face one another around an open area promotes exchanges.

If you call attention to disagreement between two findings, you invite evaluative comments and suggestions — which may lead to further meaningful discovery activities. Announcing that one child is right and another one wrong rarely leads to further discovery experiences. Instead, such action encourages children to ask you, as the authority figure, for the answers; it reduces their commitment to independent investigation — which is fundamental to an understanding of science.

Asking questions. The questions you ask and the way in which you ask them will affect the children's work and attitudes. Note the difference between "What did we study yesterday?" and "What did you find out yesterday?" Though both questions call for review of a previous activity, the former only seeks an answer already in the teacher's mind. The latter inquires into a child's own experience.

A question that aims for a predetermined answer is often called *convergent* because of its specific goal. Most questions in multiple-choice tests are of this nature (as are many questions asked by some teachers). A question that allows a variety of answers is often called *divergent* because it may lead in many directions. Provocative discussion questions are usually of this nature.

Suit your questions to your purpose. If you wish to gather feedback about understanding or recall of a certain fact, ask a convergent question. Often this is best done individually, perhaps while small-group work is in progress. When you are looking for a specific answer, make this clear to the child.

If you wish to spark discussion ask a divergent question, and then sit back while several children propose answers. If the children continue their discussion without your leadership, so much the better.

Language development. During extensive use in urban, rural, and suburban schools, the earlier SCIS program proved to be particularly helpful in improving children's oral language skills. Experience with the program was especially effective in the case of disadvantaged children, whose desire to participate in class discussions increased greatly.

In SCIIS we have increased the suggestions and ac-

tivities especially designed to encourage oral and written language development. The addition of Extending Your Experience cards, for example, encourages language development, since the child is asked to describe orally, write about, or prepare a display about the results of the activity.

Mathematics development. The SCIIS program can also do much to encourage children's development of mathematical concepts and processes. Children are urged at all levels to consider the quantitative aspects of their observations and activities. For example, in the *Material Objects* unit (Level 1) the child's concept of number is reinforced by having the child select a specific number of objects as indicated by a numeral card you display. Later, in *Subsystems and Variables* (Level 3) and *Environments* (Level 4) the use of quantitative measurements to produce histograms and graphs is emphasized. Such use of quantitative data provides opportunities for reviewing mathematical concepts, processes, and skills. For many children the introduction to histograms and graphing will be their first experience with these powerful mathematical tools.

Children new to the program. The great appeal of SCIIS derives from its reliance on direct experience, and most children will learn quickly how to participate effectively. However, a few may have difficulty because they lack background or are not accustomed to working independently. You can take several steps to make the transition easier for them.

First, all units after Level 1 begin with a review. By supplementing the review with appropriate activities and EYE cards from previous units, you can help children become familiar with concepts introduced earlier in the program. Use these activities individually or with groups.

Second, you can help a child gain confidence in independent work by showing him or her that there are often a number of alternate acceptable procedures and results in an activity. Encourage the children to find various ways to use pieces of equipment, commend their ideas, and let them share their findings with others.

Ecosystems: An Overview

To begin their investigations in Part One, your pupils build aquarium-terrarium systems that contain separate areas of water and soil. They plant grass, clover, and pea seeds in the terrarium and later add aphids and lady beetles. To the aquarium they add algae, hornwort, daphnias, snails, and guppies. As they observe events in the aquarium-terrarium systems, the children review the concepts introduced earlier in the SCIIS life science sequence. The term ecosystem is then introduced to refer to the system composed of a community of organisms interacting with its environment.

The interactions in an ecosystem include the interchanges, or cycling, of materials between organisms and their environment. Children discover evidence of the water cycle in Part Two when they investigate the evaporation and condensation of water in their aquarium-terrarium systems. They relate this cycle to the evaporation and condensation of water outdoors.

Using bromothymol blue as an indicator of the presence or absence of carbon dioxide, your pupils investigate the exchange of carbon dioxide and oxygen between plants and animals. This interchange is designated the *oxygen–carbon dioxide cycle* in Part Three. The children find that snails produce, and hornwort plants use, carbon dioxide when exposed to light. Another set of experiments leads your pupils to infer that in the dark, both plants and animals produce carbon dioxide. These observations enable the children to describe the oxygen–carbon dioxide cycle.

The food-mineral cycle is introduced in Part Four through a review of food transfer among producers, consumers, and decomposers, and the release of minerals as a result of decomposition. Diagrams of the oxygen–carbon dioxide, food-mineral, and water cycles illustrate the exchange of materials in an ecosystem.

In using pictures of various natural ecosystems and a map, the students discover the distribution of different ecosystems in the United States and Canada and identify the ecosystem in which they live.

In Part Five your pupils investigate various aspects of water pollution. They define *pollutant* as a substance added to an ecosystem in a quantity harmful to certain organisms. The children investigate the effects of various pollutants and relate these to changes on the Cycles in an Ecosystem chart. *Pollution* is presented as a sequence of changes in which the normal ecological cycles are disrupted; thus, the presence of a pollutant affects the entire ecosystem. The children's awareness of pollution problems in their environment will enable you to relate the study of *Ecosystems* to current events.

The student manual is designed to help your pupils keep a record of experimental data. It also contains problems concerning the ecosystem outside the classroom.

Concepts. The children's investigations involve them in the use of the following major concepts:

ecosystem	**water cycle**
pollution	**oxygen–carbon dioxide cycle**
	food-mineral cycle

In addition, the following minor concepts are introduced: condensation, evaporation, precipitation, tundra, taiga, deciduous forest, desert, rain forest, grassland, and pollutant.

Part One

RAND McNALLY
SCIS

Classroom Ecosystems

OBJECTIVES

To use terms introduced in previous life science units for explaining changes that occur in aquarium-terrarium systems.

To use the term ecosystem in referring to a community interacting with its physical environment.

BACKGROUND INFORMATION

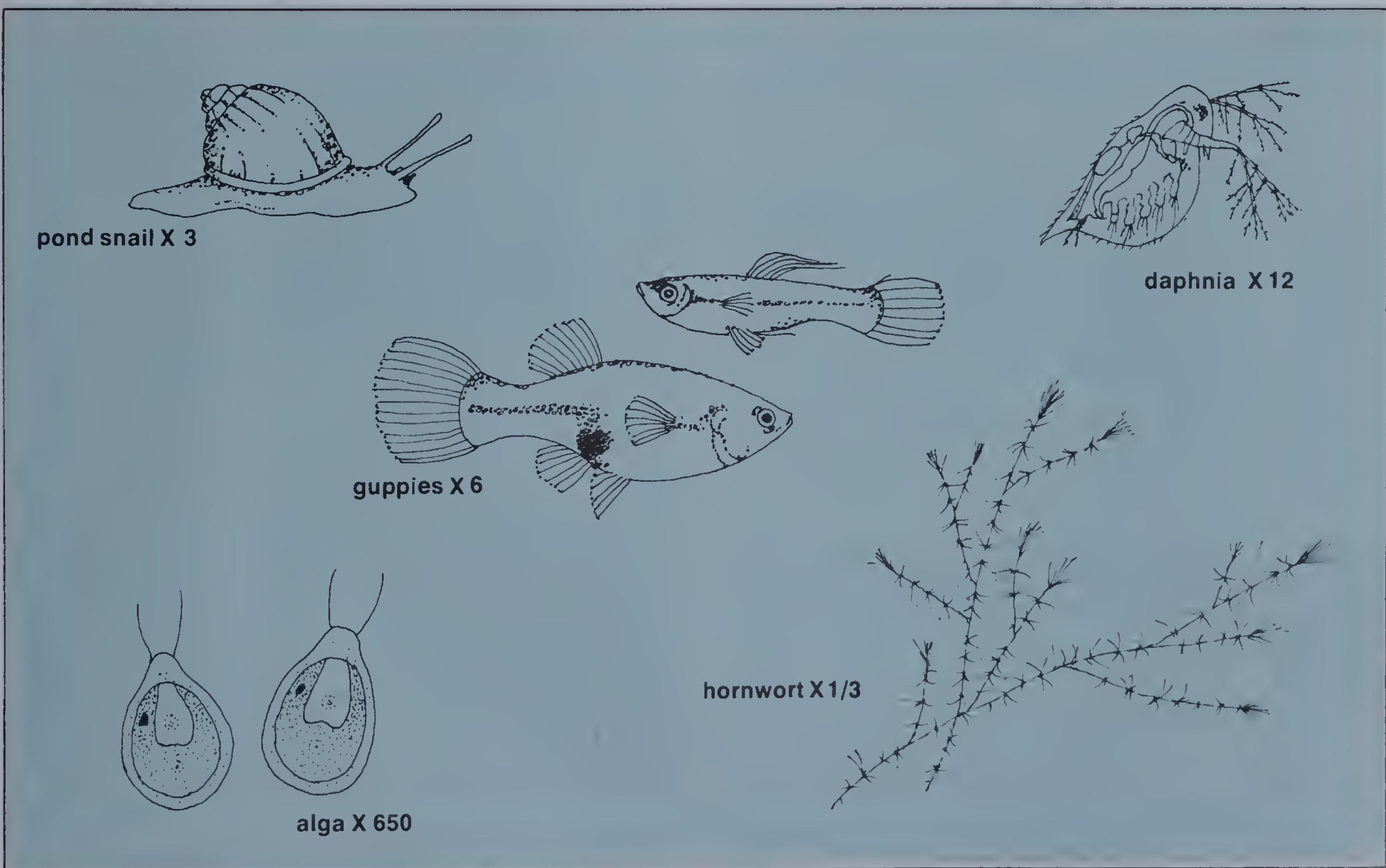
Populations of plants and animals that live in the same area and depend on one another for food and other requirements constitute a *community*. The populations form part of the community because of the interactions that occur among them. Some populations interact with others by providing shelter: trees may shelter birds and insects, for instance. Others may provide protection and companionship, as dogs do for humans. But the most obvious and important interactions in a community are feeding relationships.

Plants are the original source of all food in the community. Using energy from the sun, plants convert water and substances from the air into their own food supply. (Minerals from the soil are added to the basic food produced by this photosynthesis.)

When plants are eaten by a plant-eating animal the plant food becomes incorporated into the body of the plant-eater. Plant-eaters are in turn eaten by other animals, the animal-eaters. Thus the animal-eater lives on the food made by plants, even though it may eat animals exclusively.

Waste materials and dead plant and animal tissues

Figure I–1. The aquarium organisms.



next provide food for the decomposers (molds and bacteria). As a result of this decomposition, the minerals in plant and animal tissues are returned to the soil, water, and air, where they again become available for the plants.

If we examine a community, we find the living and dead organisms within it interact not only with each other, but with the nonliving environment as well. Environmental factors, such as heat and light, are essential to the maintenance of organisms. Light must be present if green plants are to make food. Water is necessary to all forms of life. Such a community of organisms interacting with its abiotic environment is known as an *ecosystem* to ecologists.

Some ecologists look upon our entire planet as one giant ecosystem. Others consider that even a small community interacting with the environment constitutes an ecosystem. And there is no general agreement about whether or not organisms in a pond and those on the surrounding land make up one or separate ecosystems. But all ecologists can agree on one idea—no organism lives alone; every organism is part of an ecosystem.

Your students will be introduced to the ecosystem concept through the concrete example of classroom aquarium-terrarium systems. As they work with these systems, they will be able to review many of the concepts introduced in previous SCIIS life science units. These concepts are noted in specific chapters.

OVERVIEW

In Chapter 1, "Building Aquarium-Terrarium Systems," the children construct the systems and plant seeds. Aquatic organisms are added in Chapter 2, "Adding Organisms to the Aquariums." Animals are added to the terrarium portions of the systems in Chapter 3, "Guppies, Lady Beetles, and Aphids." The concepts food chain, populations, reproduction, and community are reviewed as students observe aphids eating plants, lady beetles eating aphids, daphnias eating algae, and guppies devouring daphnias. In Chapter 4, "Changes in the Aquarium-Terrarium Systems," children attempt to relate changes in the systems to environmental factors. In Chapter 5, " 'Inventing' *Ecosystem*," the community and its environment are considered together, and the invention of the ecosystem concept follows. The latter concept is broadened in subsequent chapters.

GETTING READY

You must order Live Organisms Shipment EC-1, containing daphnias, hornwort, snails, and algae, at least three weeks before you plan to begin Chapter 2.

Live Organisms Shipment EC-2, which contains aphids, lady beetles, and daphnias, is needed for Chapter 3 (see "Schedule of Activities," page 116). Be sure to record on your calendar the arrival dates you requested.

Before doing any work in the classroom with living organisms, be sure to read "SCIIS Plants and Animals," pages 106–113.

1 Building Aquarium-Terrarium Systems

SYNOPSIS

Your students build aquarium-terrarium systems. They put soil and seeds in the terrarium part of each system, and add sand and water to the aquarium.

Suggested time: ***one class period***

TEACHING MATERIALS

For each child:

Drawer 1

student manual pages 2 and 3

For each team of four children:

1 pound of sand ‡

Drawer 4

seeds (6 pea, 2 pinches clover, 2 pinches grass)

Drawer 5

1 plastic island
1 thermometer

Drawer 6

1 six-liter container

For the class:

soil‡

Drawer 2

2 light sources

Drawer 4

18 tumblers
8 planter cups
8 planter bases
32 pea seeds
4 water sprinklers

Drawer 5

4 fluted containers

‡ Sand and Soil box

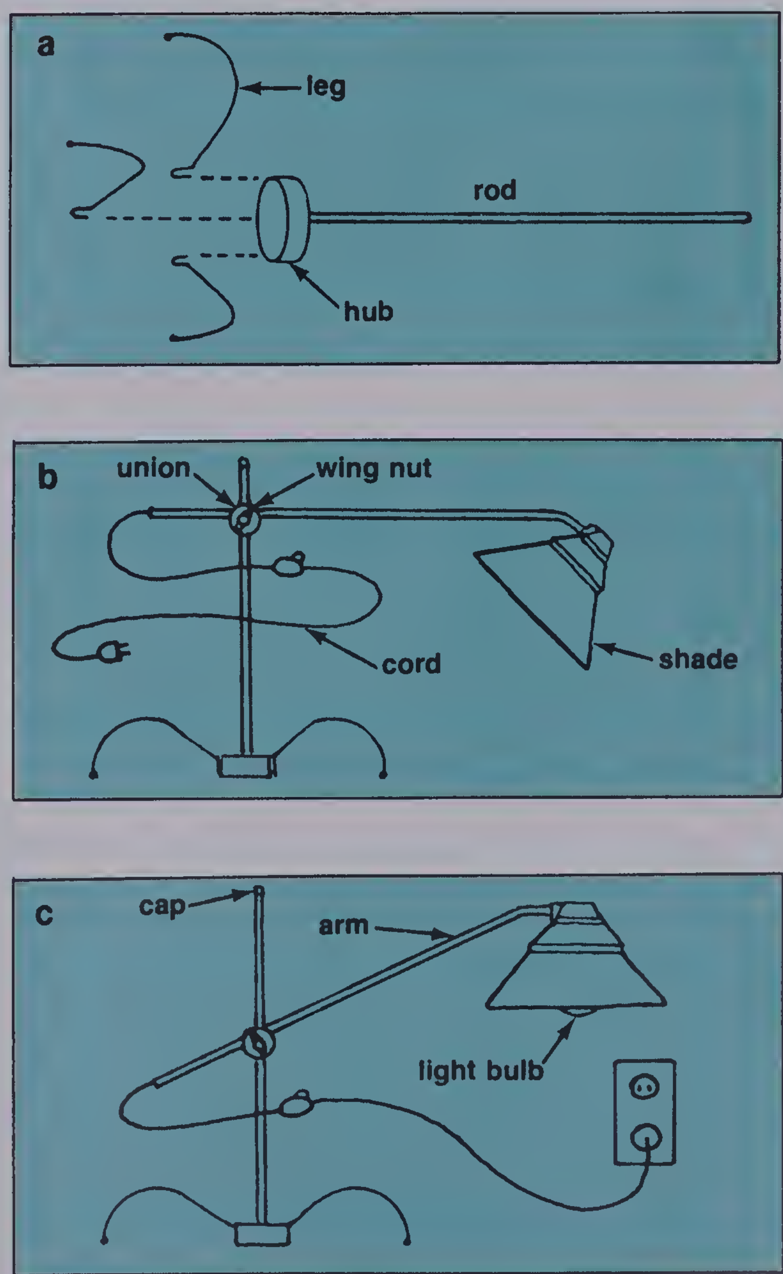
ADVANCE PREPARATION

You will find two light sources partly assembled in the kit. Use the directions in Figure 1-1 to finish assembling them before beginning this activity.

Rinse the sand for the children's aquariums to remove the powder that results from abrasion during shipping. To do this, place about three cups of sand in a fluted container, fill the container with tap water, stir the sand and water together, and pour off the water with debris from the sand. Repeat this several times until the water clears a few seconds after stirring. Clean the entire bag of sand.

Set up distribution stations around the room for sand, soil, and labeled cups of seeds. Several empty cups may be used as scoops for the sand and soil. The

Figure 1–1. (*a*) Firmly push the legs into the bottom of the hub. Set this assembly upright. (*b*) Unwind the cord, loosen the wing nut, and push the rod through the union. (*c*) After lowering the union and rotating the arm to the desired position, tighten the wing nut. Keep the bottom of the shade parallel to the table. Cap the rod and add the light bulb.



children may assist you in setting out these materials.
(The planter cups, bases, and additional pea seeds will be needed later in this chapter.)

TEACHING SUGGESTIONS

Several concepts introduced in previous units will be reviewed in the next few chapters. These are *environment, environmental factor, population, food chain, reproduction,* and *community*. Hence these chapters will be discovery lessons for most children.

Constructing the aquarium-terrarium systems. You might begin this activity by asking your students what previous experiences they have had with plants and animals in the classroom. By the children's responses you will know whether they have used previous SCIIS units and how well they remember them. After asking the children to recall their previous experiences, tell them they will construct a new sort of system, one that contains both an aquarium and a terrarium. They will begin, in this session, with the soil and water; in later chapters they will add plants and animals.

Divide the class into teams of four. Hold up the plastic island to be used as a terrarium and ask each team to place their island inside the 6-liter container. Each team can then nearly fill the terrarium section of the container with soil. The soil can be watered until it is thoroughly dark and damp, but no water should stand on the soil surface.

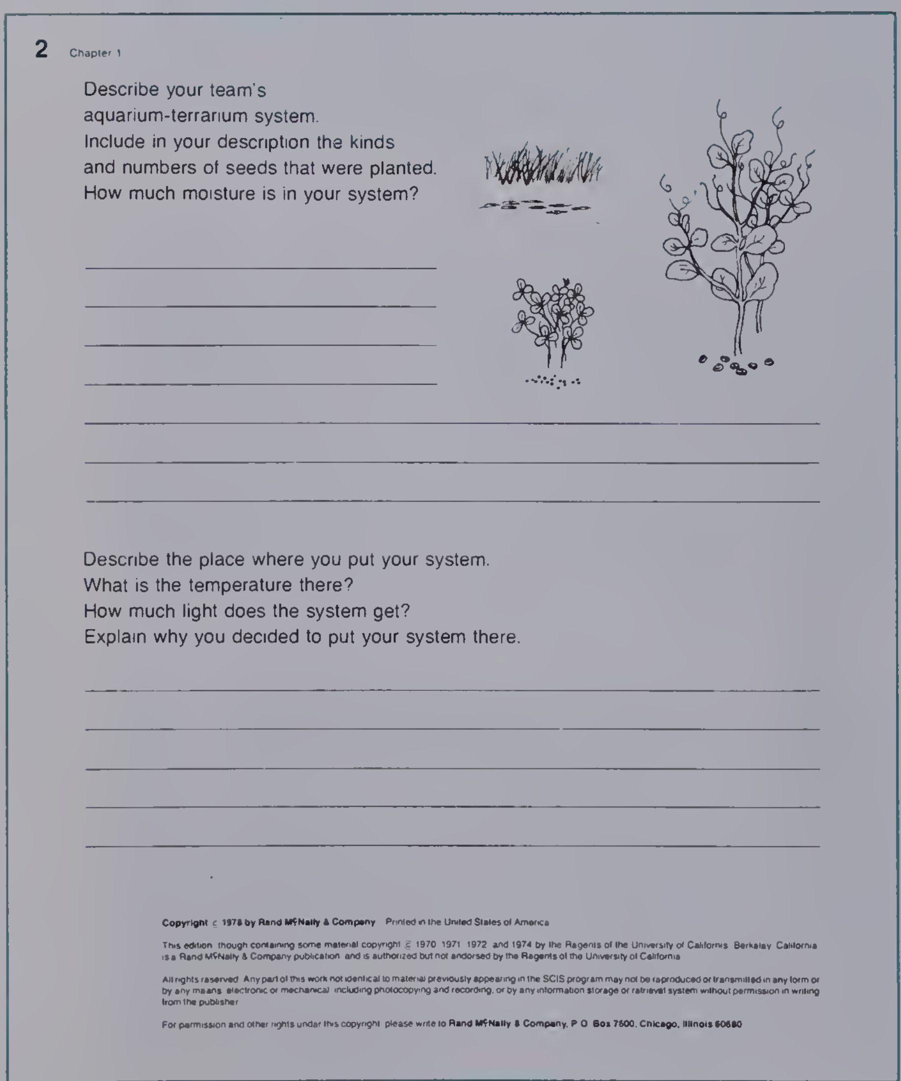
Using student manual pages 2 and 3. You may have to remind the children to write their names on the manuals.

Page 2 is intended to stimulate children's observations as they construct their systems. The information the students record on this page can be used in Chapter 4 when they describe changes in the aquarium-terrarium systems. The map on page 3 provides a record of where the three kinds of seeds are planted.

Planting seeds. Let each team decide how to plant the seeds; you might suggest, however, that the seeds be planted in a pattern that will allow easy identification after germination. The student manual map will also help in later identification.

Have the children add a layer of sand about 2.5 cm (1 inch) deep to the aquarium section surrounding the terrarium. Then, using a tumbler, they should fill the aquarium with water to a depth of about 5 cm (2 in). Each system can be labeled with the names of the team members.

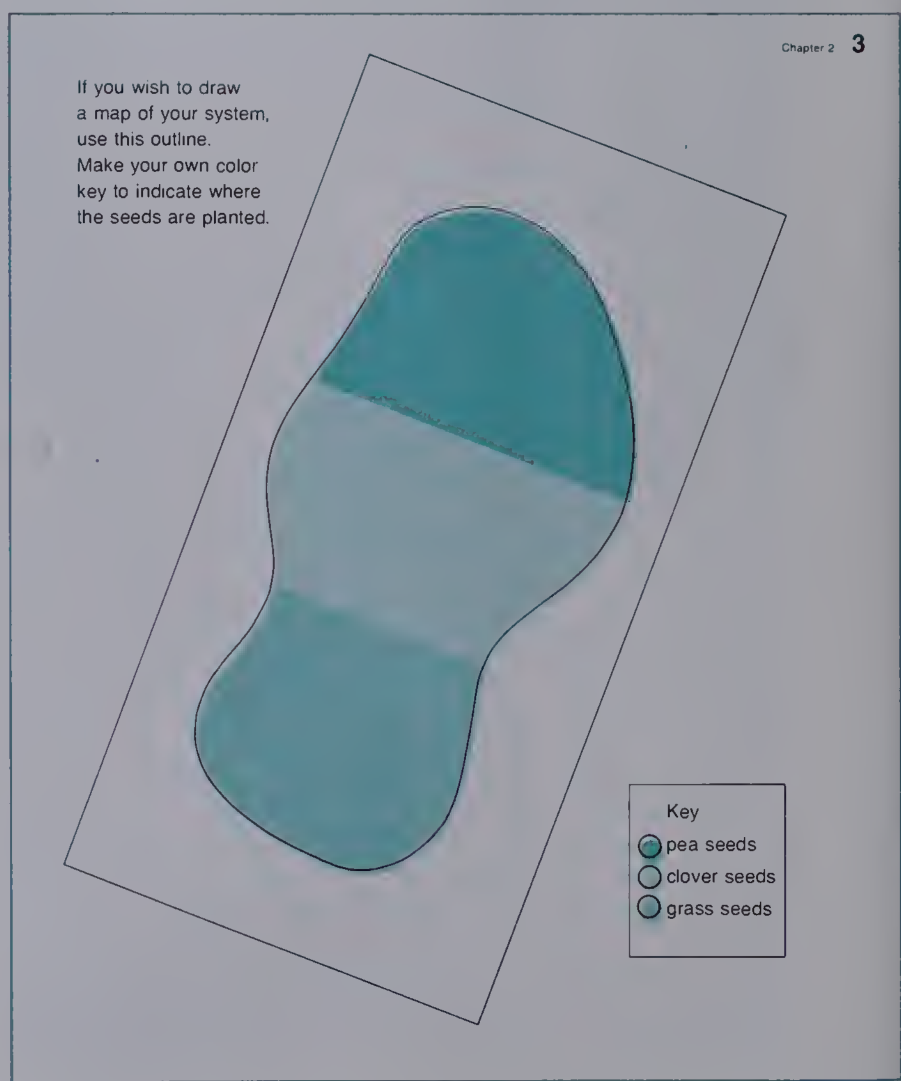
Suggest that the systems be placed around the room, wherever the teams think conditions will be


2 Chapter 1

Describe your team's aquarium-terrarium system.
Include in your description the kinds and numbers of seeds that were planted.
How much moisture is in your system?

Describe the place where you put your system.
What is the temperature there?
How much light does the system get?
Explain why you decided to put your system there.

Figure 1–2. One child's terrarium map.



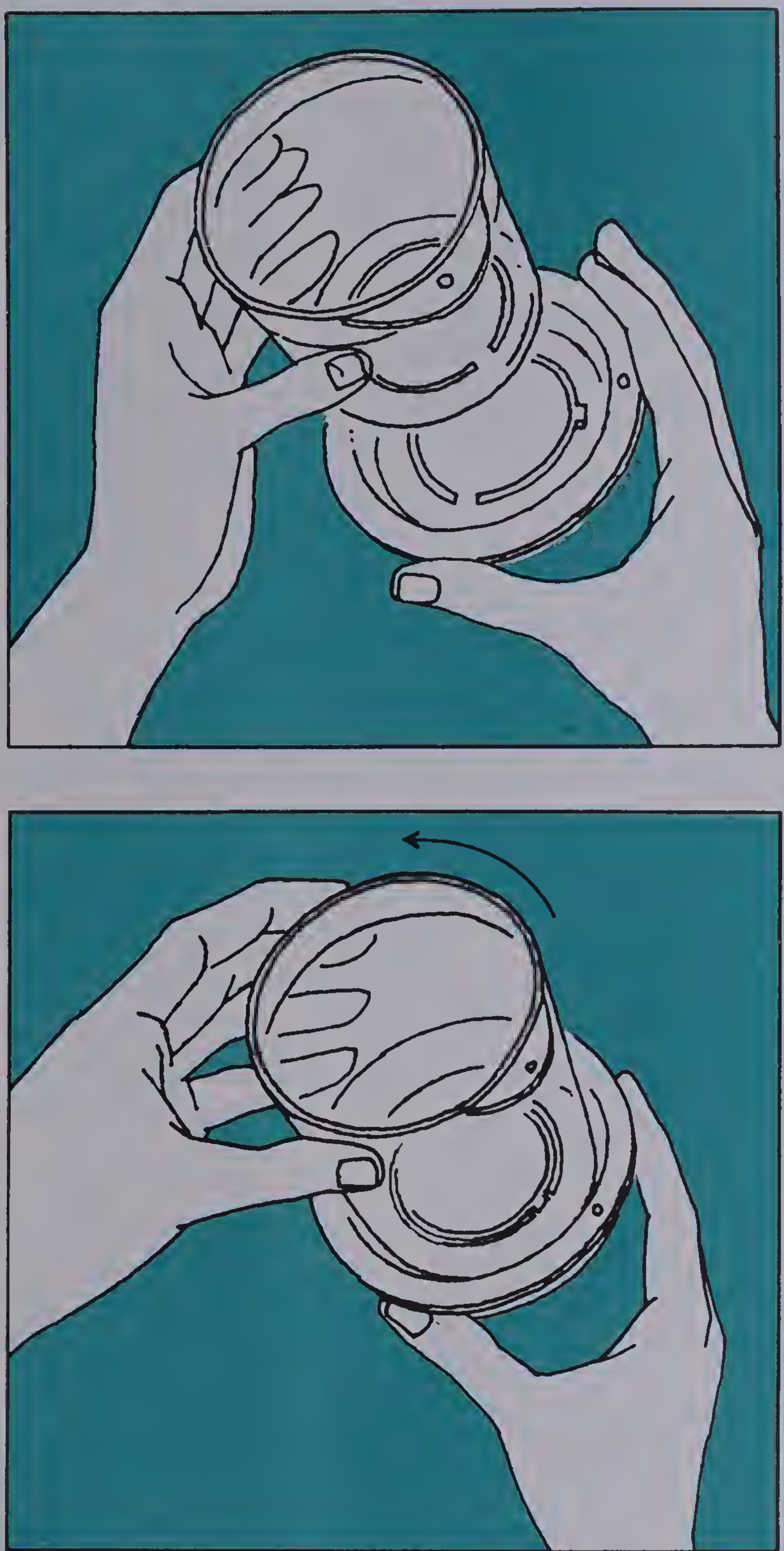


Figure 1–3. Before planting the pea seeds, the children should assemble the planters as follows: Push the planter cup into the base, then turn until you feel the two parts lock together. The planter-stick holes will now be aligned.

best for the development of the plants. Mention that light sources are available, and one may be shared by as many as four teams.

Taking care of the systems. Leave the water sprinklers near the systems, so that the children may water the soil when it is necessary. Caution them not to overwater. In fact watering may be unnecessary, because the terrarium section does not have any drainage holes in the bottom. The water in the aquariums should stand for at least twenty-four hours before organisms are added.

Cleanup. Save extra soil and seeds for future activities. Tumblers and fluted containers can be rinsed, dried, and returned to the kit.

GETTING READY

To provide pea plants for later use, have the children plant pea seeds now. Distribute a planter cup and base to each team. Tell the children to (1) fill the cups with soil, (2) plant four pea seeds in each one, (3) label each cup with their names and the date, and (4) place the cups near a light source. The plants must be watered regularly.

At least one day before you expect to receive Live Organisms Shipment EC-1, age some tap water in fluted containers as directed on page 8.

2 Adding Organisms to the Aquariums

SYNOPSIS

The children add aquatic animals and plants to the aquariums and record their observations in the student manual.

Suggested time: ***one class period for adding the organisms. The class observations will extend over several days.***

TEACHING MATERIALS

For each child:

student manual page 4

For each team of four children:

aquarium-terrarium system (from Chapter 1)
10 to 20 daphnias†
2 sprigs hornwort†
3 snails†
soil‡

For the class:

aged tap water*
algae culture†

Drawer 2

light source

Drawer 3

dip net
baster
fertilizer pellets

Drawer 4

8 plastic tumblers

Drawer 5

6 fluted containers

* provided by the teacher
† in Shipment EC-1
‡ Sand and Soil box

ADVANCE PREPARATION

At least one day before you expect to receive Shipment EC-1, fill each fluted container three-quarters full with water. (When tap water is exposed to air for twenty-four hours, its chlorine content is reduced below the level that is harmful to organisms. We call this aged tap water.)

Receiving organisms. Let the children help you with the following procedures when the organisms arrive.

- Divide the algae among four of the fluted containers of water and add four or five fertilizer pellets to each. Each container is now an algae *culture* (a laboratory "crop").
- Add the daphnias to one of these four algae cultures. To do this, pour the contents of the daphnia jar through a dip net, discarding the liquid. Then turn the dip net inside out and dip it into the algae culture to wash the daphnia from the net.
- Place all four cultures under a light source. Three will be class algae cultures. The fourth will be the class daphnia culture.
- Place the hornwort plants and snails in the fifth container of aged tap water. Use this container and the sixth one as sources of aged tap water for maintaining water levels in the cultures and in the aquariums.

Maintaining the cultures. Stir the cultures each day to keep the algae from settling to the bottom. If any algae cultures appear to be dying (becoming lighter green), add five or six fertilizer pellets. To provide food for the daphnias add about two basterfuls of green water from an algae culture each day. Maintain the original water level of all cultures with aged tap water.

Distributing materials. Let students prepare a tumbler containing organisms for each team according to this procedure:

- Using a baster, fill eight tumblers with algae culture.
- Scoop daphnias from the classroom culture into a dip net and transfer ten to twenty daphnias to each tumbler.
- Break the hornwort sprigs into pieces so that each team will have two pieces. Add these and three snails to each tumbler. Extra snails may be distributed among the aquariums or placed in an algae culture.

Figure 2–1. Preparing daphnia cultures.

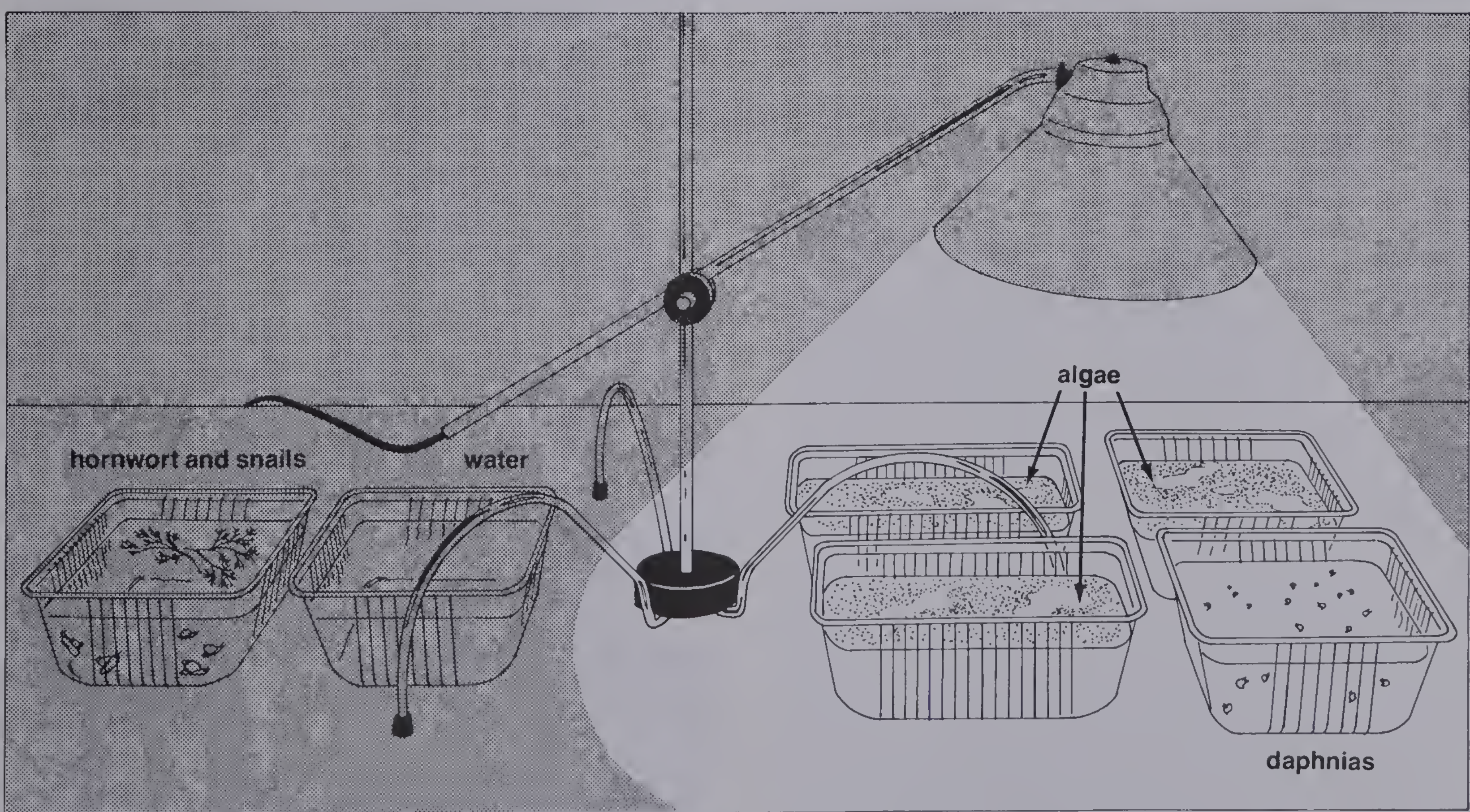


Figure 2–2. Class algae and daphnia cultures, hornwort and snails, and aging tap water.

TEACHING SUGGESTIONS

Because most of the students will have built aquariums before, this is a discovery experience.

Observing the organisms. Distribute a tumbler containing organisms to each team and tell the students they will add these organisms to their aquariums. Write the names of the organisms on the chalkboard as you identify them. Encourage the children to observe them before they pour the contents of the tumblers into their aquariums.

Using student manual page 4. Your pupils should record the names, descriptions, and numbers of organisms they added to their systems. The children may wish to draw the organisms rather than describe them in writing. Observations made in later chapters can also be written on this page. Children should refer to this page when they review food chains in Chapter 3.

Cleanup. Rinse the tumblers and store them for future use. Do not use soap or detergent. Use an eraser to remove the names from the frosted rims of the tumblers.

4 Chapter 2

Date________________

Name of organism	Drawing or description	How many?	What do they eat?

3 Guppies, Lady Beetles, and Aphids

SYNOPSIS

Children add guppies to their aquariums, lady beetles and aphids to their terrariums.

The concepts of **population, reproduction, food chain,** *and* **community** *are reviewed.*

Suggested time: *several class periods*

TEACHING MATERIALS

For each child:

student manual pages 5-7

For each team of four children:

pea seedlings (from Chapter 1)
aquarium-terrarium system (from Chapter 1)
4 guppies†
10 aphids†
5 lady beetles†

Drawer 3

1 pipe cleaner

Drawer 6

container lid

For the class:

aged tap water*
magnifiers*
felt pen or crayon (black)*
masking tape*
daphnias†
cheesecloth*

Drawer 1

1 Ecosystem chart
Community label

Drawer 3

4 dip nets
4 tumblers

* provided by the teacher
† in Shipment EC-2

ADVANCE PREPARATION

At least two days before you expect Shipment EC-2 to arrive, age two containers of tap water. When the organisms arrive, transfer the guppies from the shipping container to the aged tap water. Use a dip net to separate the daphnias from the liquid in which they came and add them to the daphnia culture prepared in Chapter 2.

Lady beetles will arrive in a plastic bottle with a screw lid. The bottle contains small holes that permit air to enter, and so you can keep the bottle closed for several days if necessary.

TEACHING SUGGESTIONS

The activities in this chapter are designed to review the concepts learned in other SCIIS units.

Transferring aphids. When the pea seedlings are about 2 cm high, tell your students that they will place aphids on the pea plants in their terrariums. Though transferring the aphids is not a simple job, your students will be more interested in the animals if they carry out the transfer themselves than if you do it for them. Demonstrate the transfer technique shown in Figure 3-1.

Figure 3–1. Gently roll a pipe cleaner beneath an aphid, lifting the aphid off the plant, and lower it onto a second plant in the same manner.

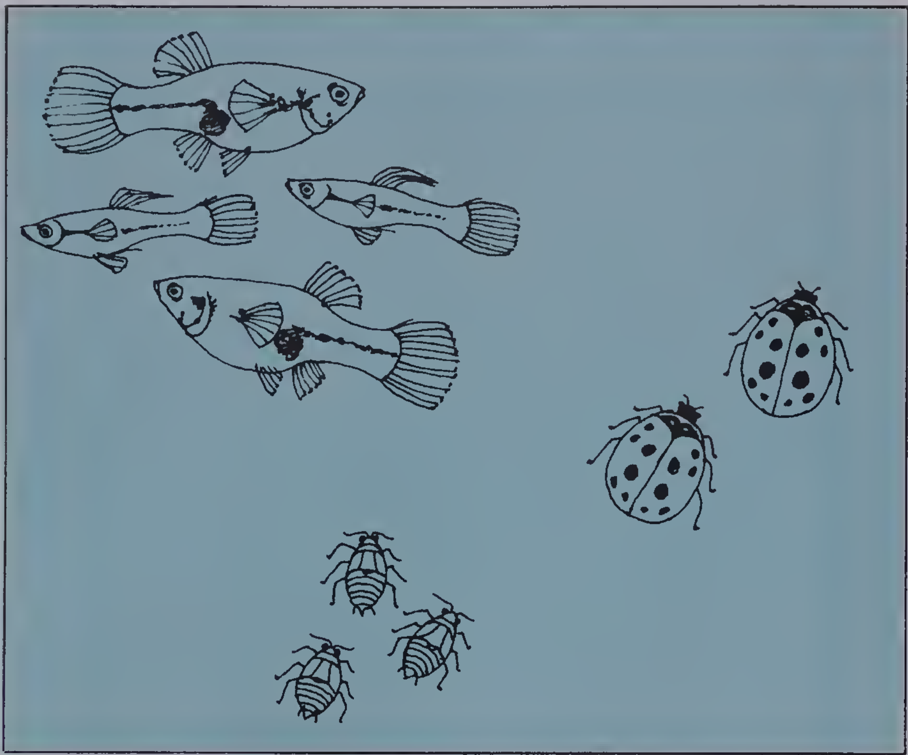


Figure 3–2. Guppies, lady beetles, aphids, (clockwise from upper left).

While the children obtain their aquarium-terrarium systems, take out a tumbler for each two teams and use a pipe cleaner to gently place about twenty aphids in each tumbler. Distribute these to the teams and ask the children to transfer the aphids to the pea plants in each terrarium.

Transferring lady beetles. After the aphids have been put in the terrariums you may distribute the lady beetles. Hold the bottle containing the lady beetles upright over one terrarium and remove the lid. The lady beetles will begin to crawl out of the bottle and walk along the edge of the mouth of the bottle. With a pipe cleaner, brush three or four beetles onto a pea plant. Move to another terrarium and repeat the process until all the beetles are distributed. Ask the children to add a layer of cheesecloth—held in place by the terrarium lids—immediately after the lady beetles are added, to prevent their escape.

Transferring guppies. The guppies should be transferred with a dip net, four in each aquarium. Soon after, the children should be able to observe them eating daphnias.

Using student manual page 5. Have the children add information about the new organisms to this page.

Reviewing *population* and *reproduction*. Student manual page 6. After several days of observation, some students may comment that one type of organism has increased or decreased in number.

Chapter 3 5

Date ____________

Name of organism	Drawing or description	How many?	What do they eat?

6 Chapter 3

Date ____________

Have any of the populations in your team's system increased or decreased?

Population	Date	Possible reason for the increase or decrease

Which population in your system is the largest? ____________

Which population is the smallest? ____________

- Explain that biologists refer to a group of the same kind of organisms living in the same area as a *population.*
- Ask the children to list on page 6 the populations in their systems that have increased or decreased.
- Notice which population they record as the largest. They should remember that the size of a population is determined by the number of organisms, not by the size of the individuals.
- If some children do not understand this, explain that although one snail may be larger than ten daphnias, two or three snails make up a smaller population than ten daphnias.

Ask the children to continue to observe their systems over several days, and to record on page 6 the populations that increase or decrease. Your students may notice that some of the organisms can no longer be found. If they believe that the missing organisms have been eaten, they should attempt to find out what organism ate them. If, on the other hand, children say that the missing organisms have died, they should look for the remains.

If some children report that the daphnia or aphid population is increasing, ask them to look for young. The cause of the increase provides a smooth transition into the review of *reproduction,* the coming into being of new members of a population.

Ask what would happen to a population of daphnias or of any other animal or plant if young were no longer produced. Your students should understand that, because individual organisms die, the population would soon disappear.

What do animals eat? Ask the children to describe any evidence of feeding among organisms in their systems. They may want to refer to their records on pages 4 and 5 of their manuals. They are likely to mention guppies catching and swallowing daphnias, and lady beetles eating aphids. If they do not recognize that aphids feed on pea plants you should tell them. Some children may remember from earlier SCIIS units that daphnias eat algae. Others may notice the fading color of the aquarium water and infer from this that the daphnias are eating algae.

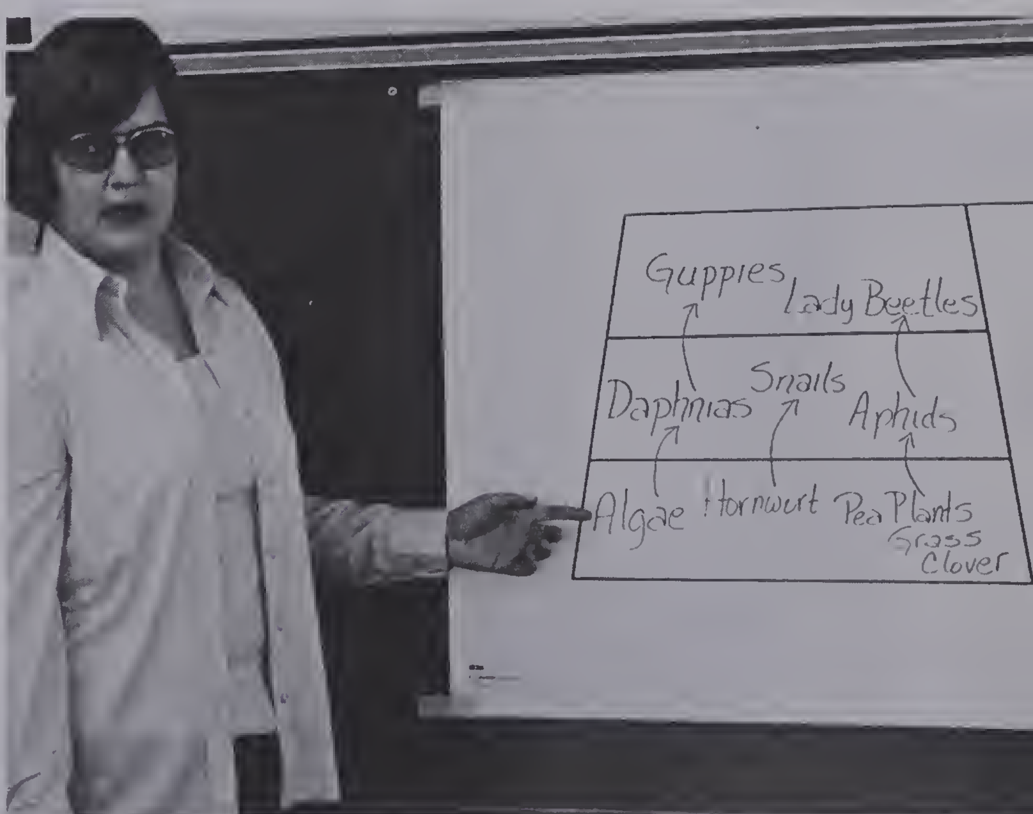
Reviewing *food chains.* Post the blank Ecosystem chart, which will be used as a class record of the feeding relationships in the aquarium-terrarium systems. (You may find it helpful to draw a similar diagram on the chalkboard during discussions; then items agreed upon can be transferred to the chart later.) Children who have studied the *Communities* unit will recognize the chart. Remind them that the names of plants are placed in the bottom section, plant-eaters in the middle, animal-eaters in the top section, and decomposers on the right.

- Tell the children that this diagram may be used to record observations they have made of some organisms eating others in their systems.
- Ask them for an example of one organism eating another in their aquariums.
- If they suggest guppies, write this word in the animal-eater section of the diagram and ask what guppies eat.
- When the children suggest daphnias, write *daphnias* in the plant-eater section and draw an arrow from this word to the word *guppies.*
- Then ask what daphnias eat.
- Write the word *algae* in the plant section and draw an arrow from it to *daphnias.*

Remind the children that this is an example of a *food chain*, which represents food transfer from a plant to a plant-eater and then to an animal-eater. In the absence of a population of animal-eaters, a food chain may consist of only a plant and a population that eats it. As an example, write the words *snails* and *hornwort* in the appropriate sections on the chart, and connect them with an arrow.

If the children have noticed that lady beetles eat aphids, write *aphids* in the plant-eater section and *lady beetles* in the animal-eater section. Draw an arrow between the two names and ask what aphids eat. Add *pea plants* to the plant section of the chart and draw an arrow to *aphids.*

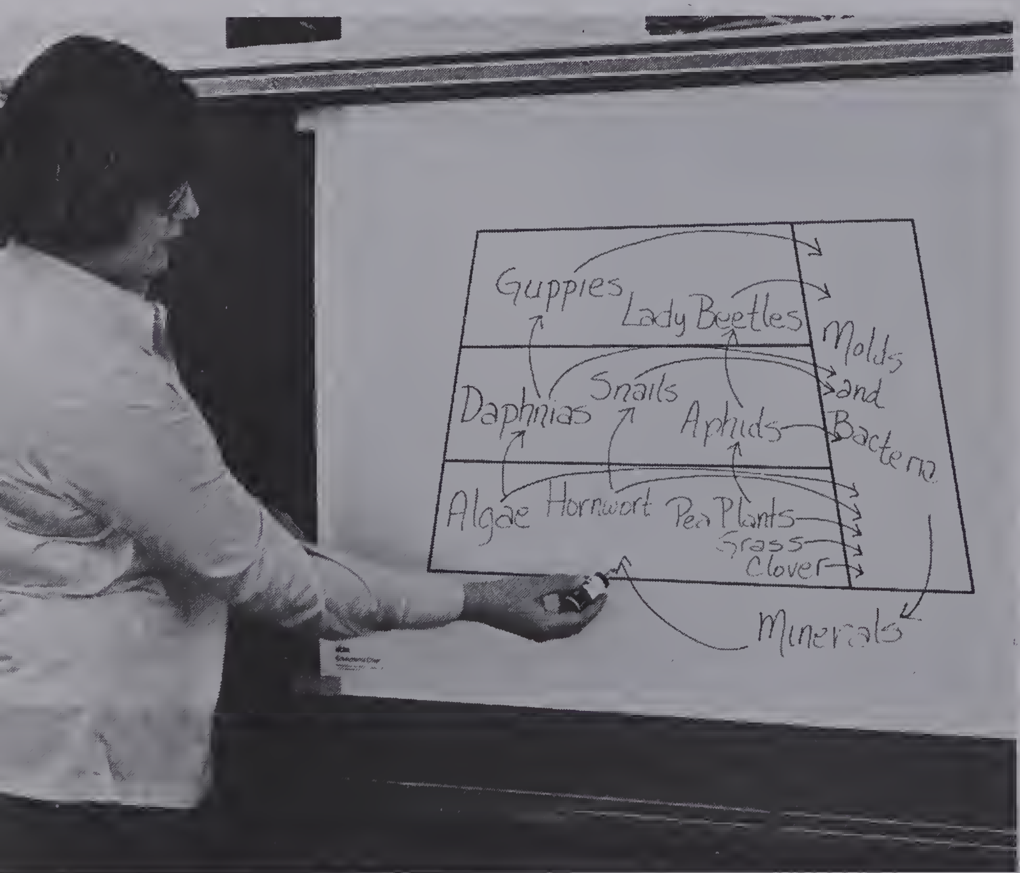
Figure 3–3. Food chains in an aquarium-terrarium system.



Adding to the diagram. During another science session, ask if any organisms in the systems died but were not eaten. Perhaps the children have observed a dead guppy or plant with a shiny spot or covered with a fuzzy growth. They may also have detected a foul odor in the system.

- If such evidence was observed, ask a student to describe what these dead organisms look like and what might be happening to them.
- Someone might suggest that the organisms growing on these dead organisms are molds and bacteria.
- If your students have not observed these phenomena in their systems, ask them what happens to organisms that die but are not eaten.
- The answer will probably be that they decay or become moldy.
- Ask what populations on the diagram might decay or become moldy when they die.
- Write *molds and bacteria* in the diagonal section on the diagram and remind the class that these are tiny organisms that decompose dead plants and animals.
- Draw arrows from the populations the students suggest to the words *molds and bacteria*.
- Now ask what happens to the dead organisms after they decay.
- Students who have studied the *Communities* unit will suggest that bodies of dead plants and animals break down and go into the soil.

Figure 3–4. Adding minerals to the diagram.



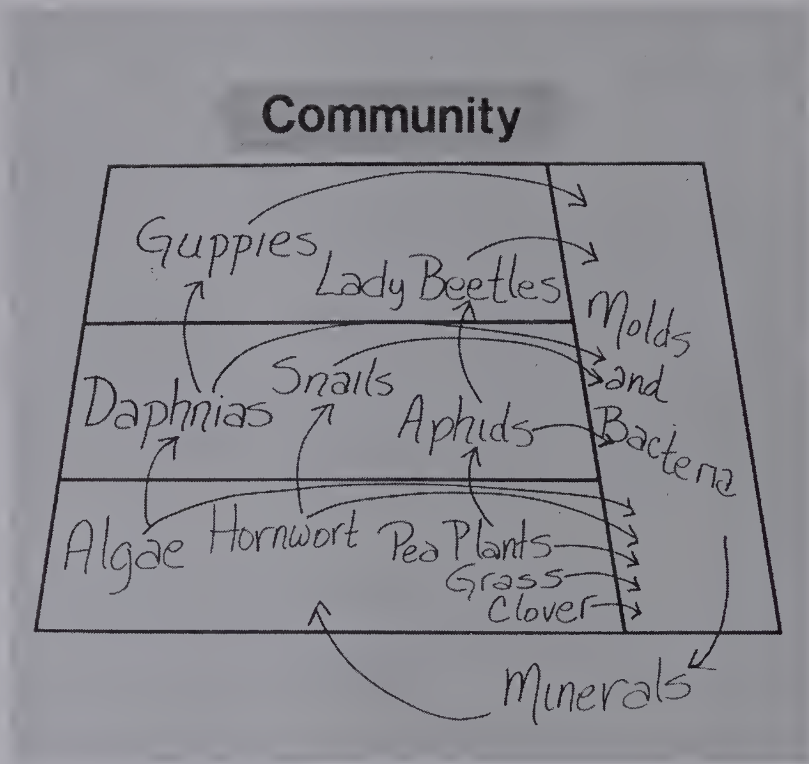


Figure 3–5. Adding the Community label.

- Remind them that through decomposition raw materials are released to the soil, water, and air, and can then be used by plants for making food.
- Ask the students to suggest various raw materials.
- They might mention water, gases, or minerals.
- Tell them water and gases will be considered later and that only minerals will be recorded now.
- Write the term *minerals* beneath the diagram.
- Draw one arrow from the words *molds and bacteria* to *minerals* and another arrow from *minerals* to the plant section.

Reviewing *community*. The diagram should now indicate food relationships among plants, animals, and decomposers. In addition, it will show that minerals are released by the decomposers and are returned to the plants. Tell the children that when populations of organisms live together and depend on one another for food and other requirements, we call this a *community*. Place the Community label above the diagram.

Ask the children to give examples of natural communities. They might suggest a pond, forest, desert, prairie, ocean, or seashore. Ask any child who appears to be familiar with such a community to name some of the plants and animals in it and to describe some food chains.

Neighborhood communities. Student manual page 7. You can use this page either to obtain feedback about how well individual children understand some aspects of the community concept or to stimulate discussion. You might invite the children to name some of the plants and animals that live in their neighbor-

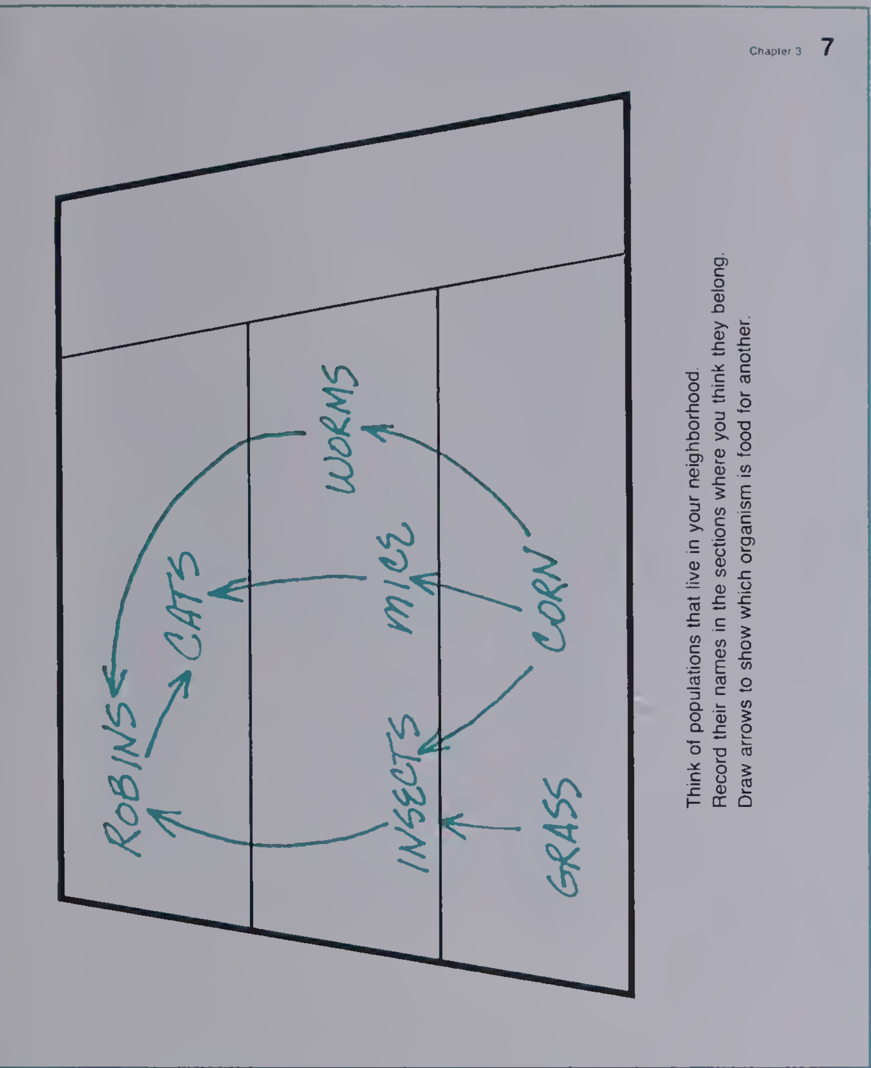
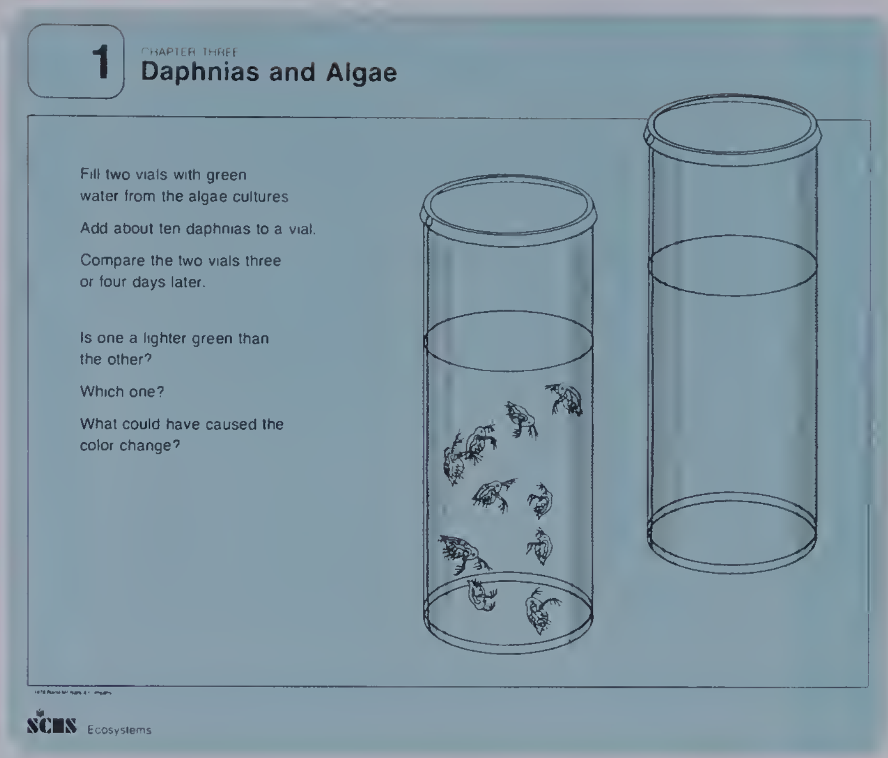


Figure 3–6. Children can think of several food chains for any neighborhood.



hood—such as trees, birds, insects, dogs, and cats.

- What do the animals eat?
- Do any of the animals depend on humans for food?
- Do any of the plants depend on humans for minerals?
- Ask the children if they think they are a part of a community of plants and animals that depend on each other for food and other requirements.

Cleanup. Rinse, dry, and store the plastic tumblers. Save the chart for use in future activities.

EXTENDING YOUR EXPERIENCE CARDS

For suggestions on using these cards, see page xvii.

1. Daphnias and Algae. For this activity, students need two vials of algae water, one containing daphnias and the other not. As the daphnias feed on the algae, the green color in that vial becomes pale.

4 Changes in the Aquarium-Terrarium Systems

SYNOPSIS

The teams examine the aquarium-terrarium systems and describe any changes that have taken place.

Some of these changes provide opportunities for reviewing the concepts of environment and environmental factors.

Suggested time: *several class periods*

TEACHING MATERIALS

For each child:

student manual pages 8 and 9

For the class:

aquarium-terrarium systems (from Chapter 1)

TEACHING SUGGESTIONS

In this activity you review concepts taught in previous units.

Reviewing *environment* and *environmental factors.* As students observe their aquarium-terrarium systems, they usually talk about changes that have occurred. Listen to their conversations and be alert for any comments that you can use for review.

- After the children have observed their systems for several days, ask what changes there have been. What seeds have germinated and plants grown? What organisms have died?
- Has a team had difficulty with its system? If so, ask about the environment in the system. Was the system too wet? Was the temperature too high or too low? Was there too much or too little light?
- Remind the children that whatever affects organisms—light, water, temperature, air, or chemicals—is called an *environmental factor*.
- Tell them also that the *environment* is the sum total of all environmental factors.
- Ask teams with successful systems to describe the environment present. Could they suggest why others failed?
- Such comparison may be easier if the children first line the systems up with each other.

Using student manual pages 8 and 9. Suggest that the children use these pages to record any changes that were caused by environmental conditions. For example, if the pea seeds rot and do not germinate, the members may attribute this to excess water in the terrarium.

Encourage them to also record questions they may have about their systems on the bottom of page 9.

Range* and *optimum. You may wish to elaborate on the concept of environmental factors by pointing out that for each factor there is a *range* within which an organism can function (grow, move, and reproduce) and an *optimum* amount of the environmental factor. For example, humans can live in a wide range of temperatures, but the optimum temperature for humans is about 18–24°C (65–75°F). A child may volunteer that what is optimum for one organism is not necessarily optimum for another.

Rebuilding systems. If seeds failed to germinate or if other organisms died, a team may wish to rebuild its system. Allow the members to do so, but be sure to question them about what might have caused their original difficulty so that the problem will not recur.

Figure 4-1. Comparing successful and unsuccessful aquarium-terrarium systems.

Describe changes you have observed in your system.
What environmental factors may have caused these changes?

Date	Change	Possible cause

Date	Change	Possible cause

What changes in your system do you have questions about?

5 "Inventing" *Ecosystem*

SYNOPSIS

As the children continue to maintain and observe their systems, the dependence of organisms on the environment becomes evident.

You introduce the ecosystem concept.

Suggested time: ***one class session***

TEACHING MATERIALS

For each child:

student manual pages 8 and 9

For each team of four children:

aquarium-terrarium system (from Chapter 1)

For the class:

Ecosystem chart (from Chapter 3)*
felt pen or crayon (green)*
masking tape*

Drawer 1

Ecosystem label
Environment label

* provided by the teacher

NOTE

The aquarium-terrarium systems, unlike the natural ecosystems they represent, will not last very long. Natural communites are balanced and may persist for years, but such a balance cannot be achieved in small classroom ecosystems. Some will last longer than others, but all will collapse in time.

TEACHING SUGGESTIONS

In this invention lesson, the ecosystem concept is introduced.

Recording changes. Student manual pages 8 and 9. Allow your students time to examine their systems, noting and recording changes that have taken place. Encourage the children to think of the environments in the systems as they try to determine the possible causes of the changes observed. These records, along with pages 2–6, will comprise a running biography of each system.

The children may mention that there is moisture on the inner walls of the 6-liter containers. Encourage them to record this change in their student manuals, but do not discuss moisture in detail at this time. This phenomenon will be investigated in Part Two.

Adding environmental factors to the chart. Post the chart on the chalkboard. As the children have been exposed to a great deal of information in a relatively short time, use the following directions to review the major concepts of population, community, and environment and to introduce the ecosystem concept.

Spend a few minutes discussing the community on the chart. The class should be aware that organisms live together because they depend on each other for food.

- Ask what things, other than food, the populations in the community require in order to live.
- Students may suggest such environmental factors as light, soil, water, and gases.
- Using the green pen, record their suggestions in the space to the left of the diagram.
- As you record each factor, ask the children which populations listed on the chart require that factor.
- Draw arrows from the factor to the sections on the chart where these populations are recorded.
- After you have listed all the children's ideas, add the *Environment* label above the list of factors.

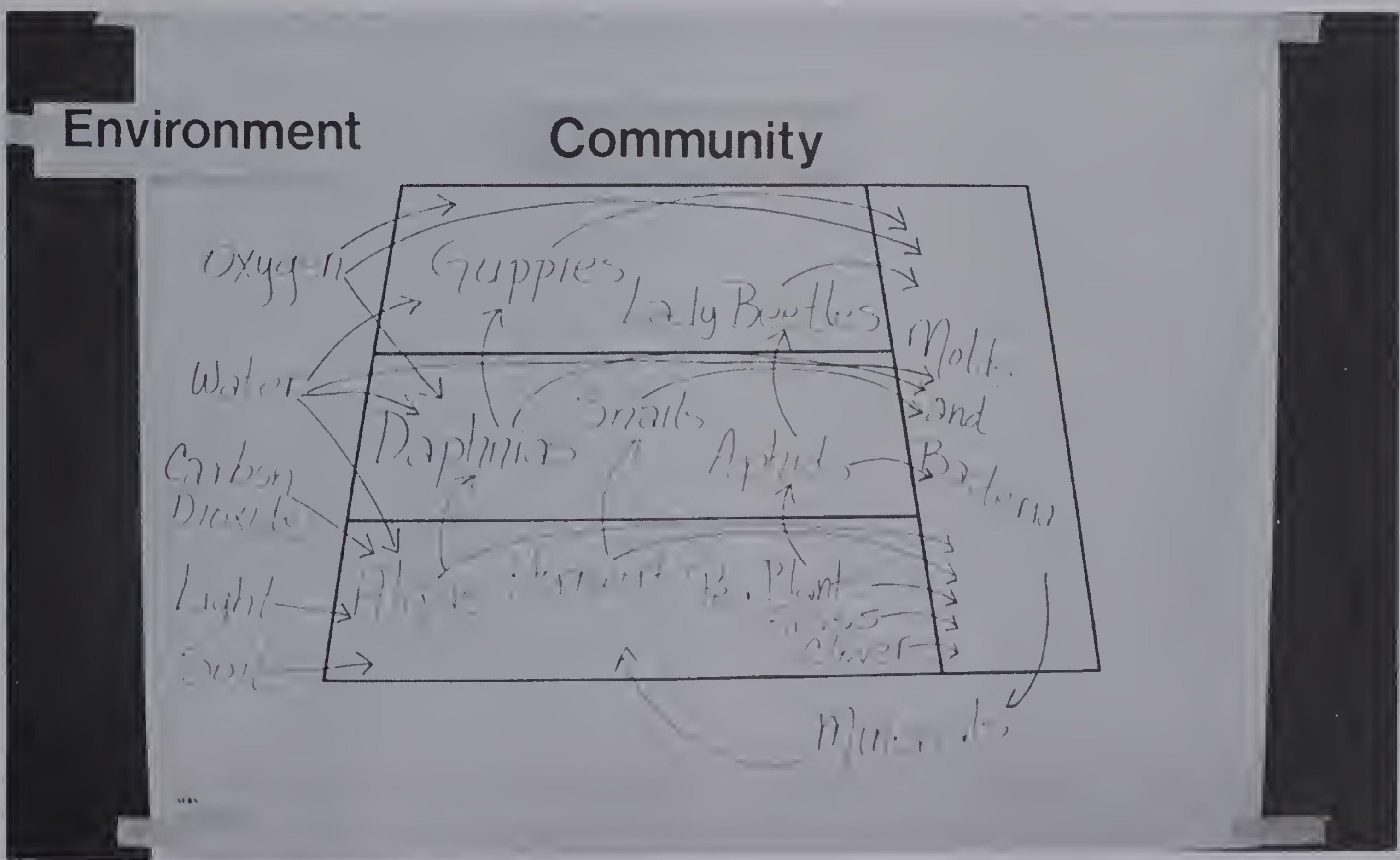
"Inventing" *ecosystem.* Explain to the class that a community interacting with its environment is called an *ecosystem*. Place the Ecosystem label at the top of the chart.

Ask your students if the systems they constructed are ecosystems. Ask them to compare the outdoor ecosystems with their aquarium-terrarium ecosystems. How are they alike? How are they different? Ideas like the following may be brought out by the children:

- There are more kinds of organisms outdoors (and thus more possible food sources) than in the classroom systems.

Figure 5–1. There will probably be some condensation inside the containers.

Figure 5-2. Various factors are summarized as Environment.



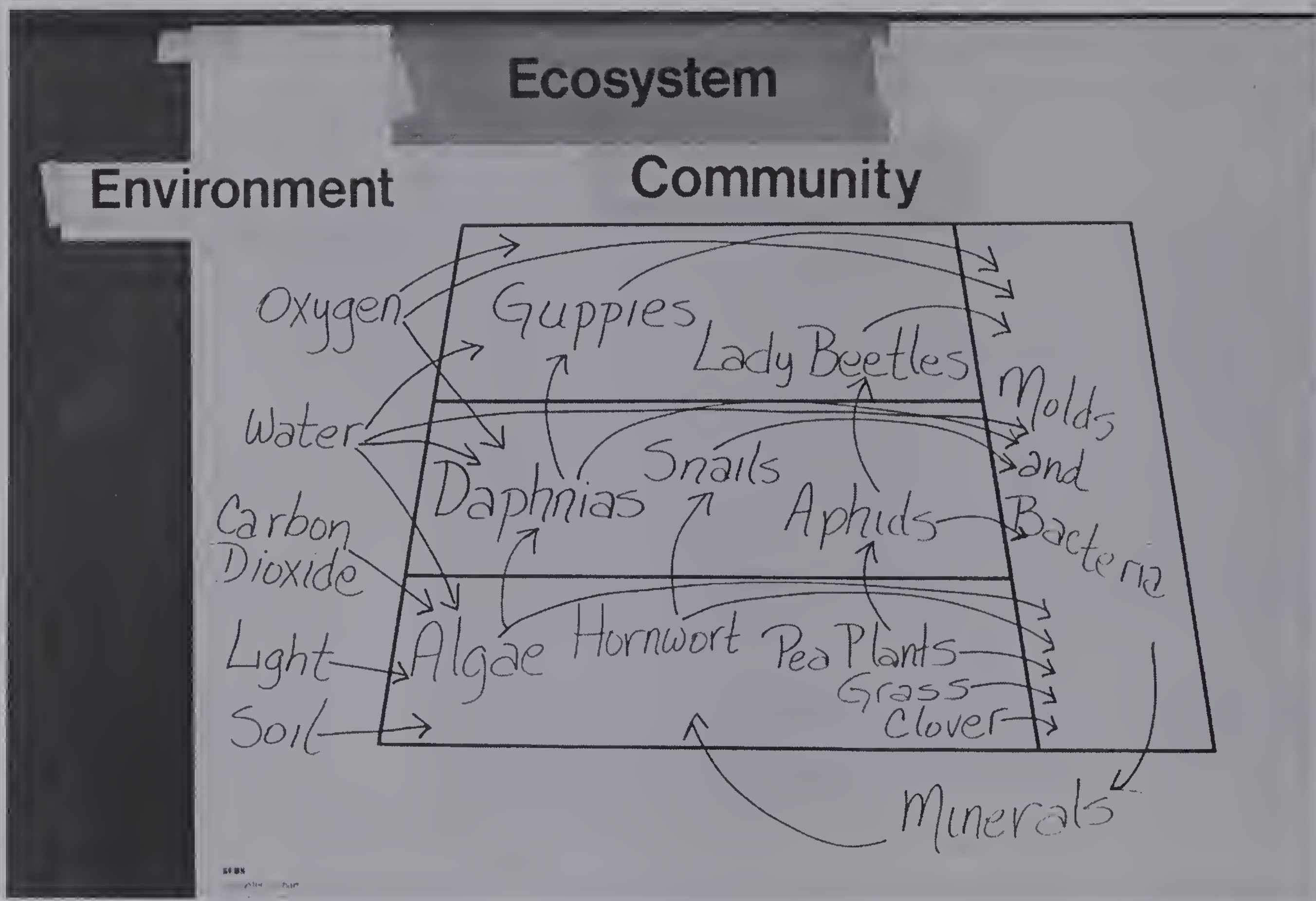


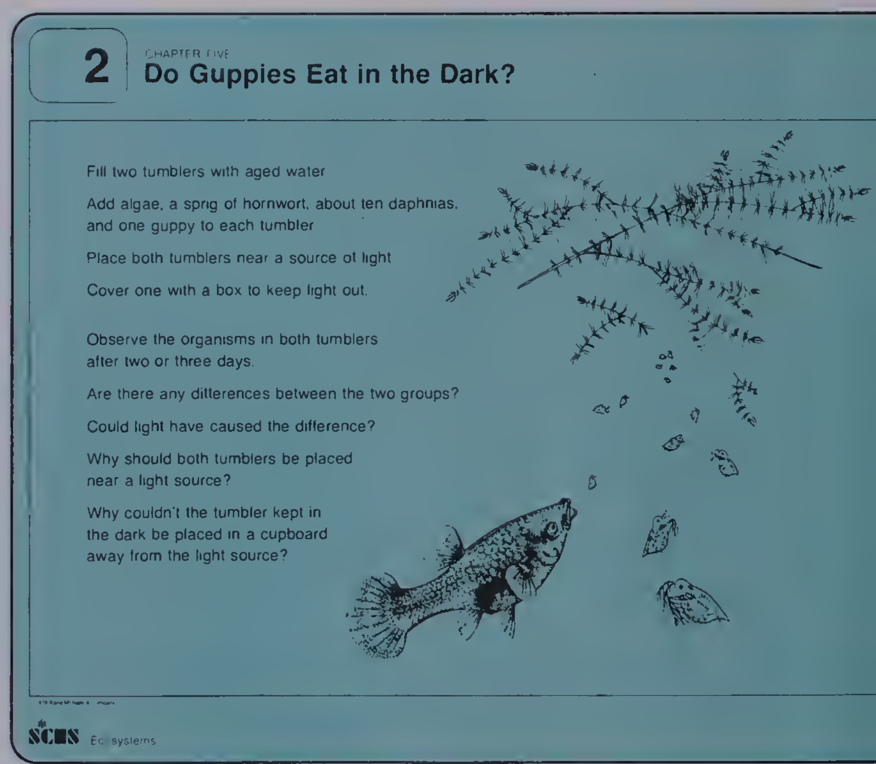
Figure 5-3. Completing the Ecosystem chart.

- Animals indoors may use up their food supply and depend on us for food. Outdoor animals can move to a new source of food.
- An animal outdoors can move to an area that provides the best conditions for survival.
- Temperatures stay about the same in aquarium-terrarium systems, but change daily and seasonally outdoors.
- Water is added to classroom systems. If there is a drought outdoors, organisms either move or die from lack of water.

EXTENDING YOUR EXPERIENCE CARDS

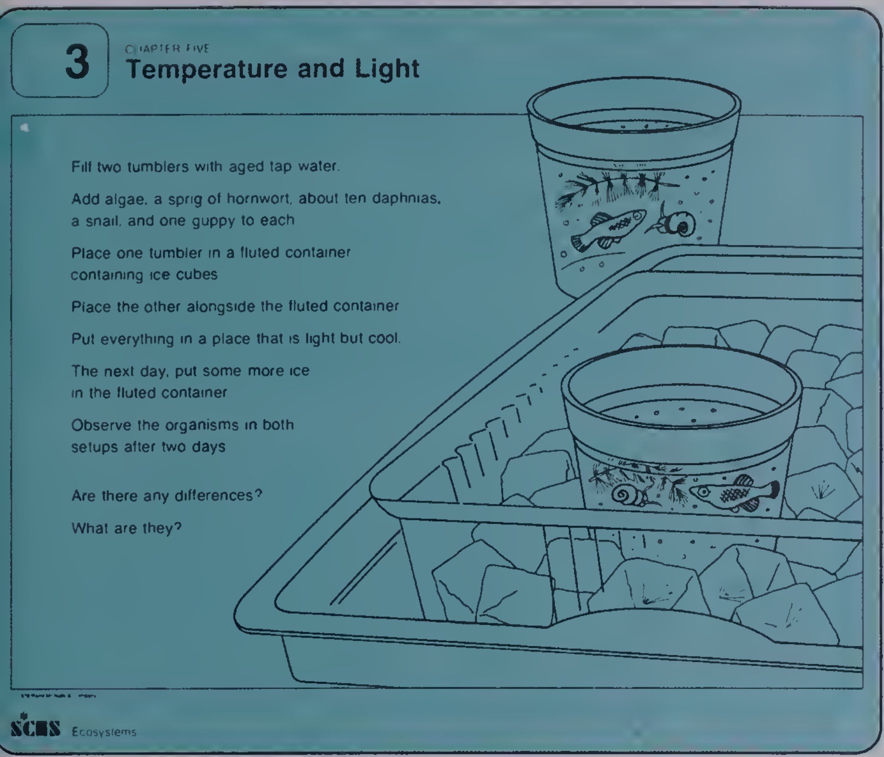
2. Do Guppies Eat in the Dark? The children experiment to find out if guppies need light to feed on daphnias. They will need two tumblers and a light source or a bright window.

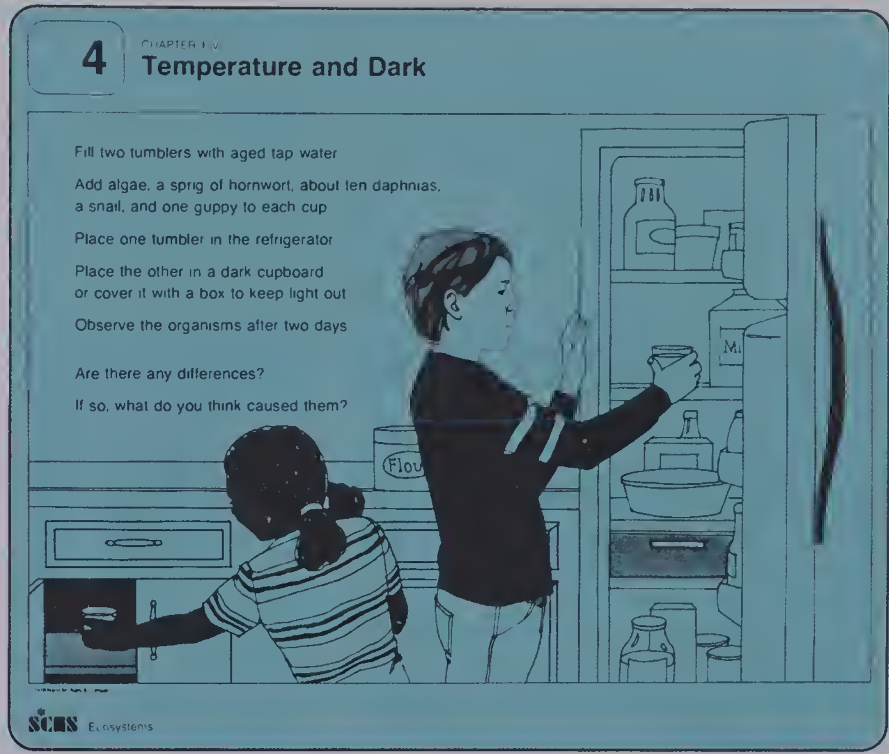
You may want to use this card to find out whether a student understands the need for an experimental control.



3. Temperature and Light. For testing the effect of low temperature on a miniature aquarium in light, the student will need two tumblers, a fluted container, and a supply of ice cubes.

4. Temperature and Dark. Students compare the effect of low temperature on a miniature aquarium kept in the dark. They will need two cups, a refrigerator, and a dark cupboard or box. Results from this activity and from Card 3 can be compared.





Extending Your Experience cards 1–4 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of classroom ecosystems, turn to page 95 of the evaluation section at the back of the guide.

Part Two

RAND McNALLY

SCIIS

The Water Cycle

OBJECTIVES

To describe conditions that are necessary for the evaporation and condensation of water.

To use the term water cycle, to refer to the evaporation and condensation of water.

To compare the experimental water cycle to the water cycle in nature.

BACKGROUND INFORMATION

Water covers about three-fourths of the earth's surface; no matter how remote a land area may be from a body of water, it receives moisture on occasion.

Earth's water cycle is familiar to most of us. Energy from the sun causes a steady evaporation of water from oceans and lakes, streams, other bodies of water, and even from land. This water vapor mixes with the air and is transported by winds.

When an air mass cools, it cannot hold as much water. The water vapor condenses, forms clouds, and eventually falls back to earth as rain or snow. Here the water may evaporate again, percolate through the soil, or run into streams that follow a downhill course to lakes or oceans.

Living organisms take up some of the water that reaches the earth. All animals begin their lives in a watery medium: eggs are fertilized, and embryos develop, in liquid surroundings. And all life processes (digestion and photosynthesis, for example) require the presence of water. Finding a source of water is not difficult for aquatic organisms, but the problem is more complicated for those organisms that live on land. Plants develop roots that absorb water from the soil; animals drink water or get it from their food.

Organisms cannot hold water in their bodies for long periods. Plants lose water through special openings on their surfaces, and the lost water must be replaced for photosynthesis and growth to take place. Animals lose large quantities of water through exhaled breath and liquid wastes. Water also evaporates to the atmosphere through pores in the skin of many animals. This water must be replaced for bodily functions to continue. Thus water is continually entering and leaving organisms.

The water cycle existed long before life ever appeared on the earth, and presumably it has always operated as it does today. The water cycle does not require organisms, but all organisms are dependent on the water cycle. Without it, animals and plants would cease to exist.

Figure II–1. The natural water cycle.

OVERVIEW

Questions stimulated by the appearance of moisture inside the walls of the aquarium-terrarium systems lead to investigations in Chapter 6, "Where Does the Moisture Come From?" In Chapter 7, "Evaporation," the students investigate the conditions that lead to evaporation of water from tumblers; in Chapter 8, "Condensation," they investigate the conditions that cause condensation. In Chapter 9, " 'Inventing' the Water Cycle," the children attempt to experimentally produce evaporation and condensation of water. After their experiments the water cycle concept is introduced.

6 Where Does the Moisture Come From?

SYNOPSIS

After children observe moisture on the inner walls of the aquarium-terrarium systems, they design and perform experiments to discover where it comes from.

Suggested time: ***one class period to set up the experiments. Thereafter, schedule brief recording and observation sessions for about a week.***

TEACHING MATERIALS

For each child:

student manual page 10

For each team of four children:

aquarium-terrarium system (from Chapter 1)
4 planters containing pea plants (prepared after Chapter 1)

Drawer 3

2 plastic bags
2 twistems

Drawer 4

2 tumblers
1 planter stick
1 vial with cap

For the class:

masking tape (optional)*
fish food pellets†

Drawer 2

light source

Drawer 3

4 dip nets
labels

Drawer 5

2 fluted containers

* provided by the teacher
† in Shipment EC-1

ADVANCE PREPARATION

If none of the children's systems shows evidence of condensation, select one that has been well watered. Cover half the holes in the lid with masking tape. Adjust a light source by lowering the arm so that the shade is just above the aquarium-terrarium system. Within about thirty minutes, moisture should appear on the inside walls and on the underside of the lid as a result of evaporation and condensation within the container.

TEACHING SUGGESTIONS

This is an exploratory activity in which the children attempt to find out the source of water that appeared on the inner walls of the aquarium-terrarium systems.

Introducing the activity. If the children have not observed and mentioned the moisture on the inner walls and lids of the aquarium-terrarium systems, place a system showing evidence of the phenomenon where everybody can see it.

- Ask the children the source of the moisture.
- If your students suggest the aquarium water, ask what other parts of their systems might also cause the moisture.
- They may mention animals, plants, and wet soil.
- Record the children's answers on the chalkboard and ask them to suggest reasons for their hypotheses also.

Figure 6–1. Demonstrating condensation in one system.

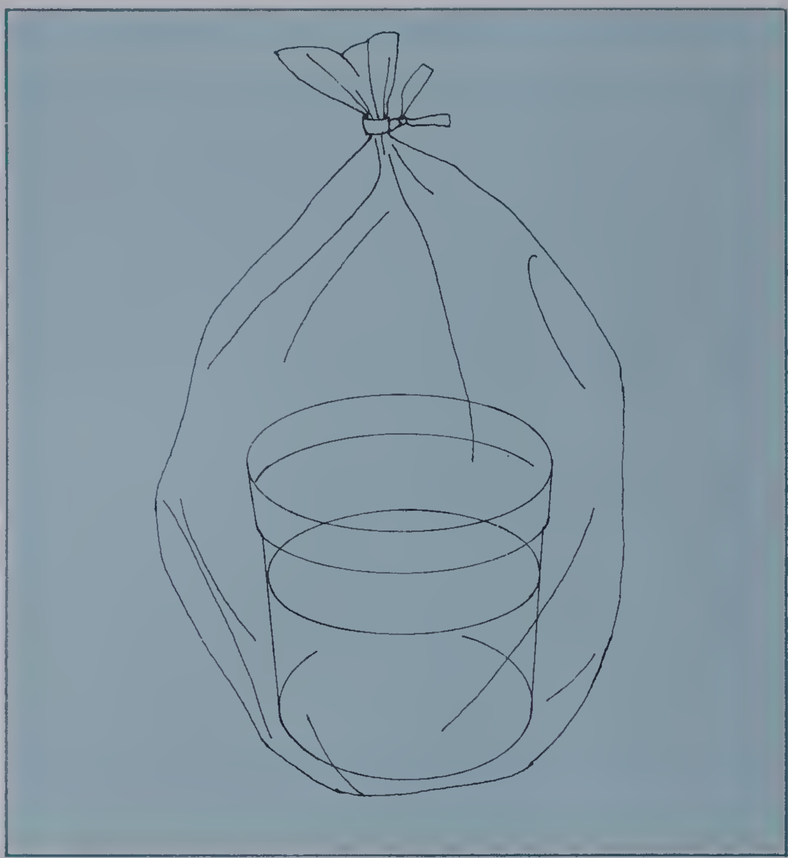


Figure 6–2. Does aquarium water produce moisture?

Designing the experiments. After the children have presented their ideas, ask how they could gather supporting evidence for their hypotheses. Tell them that four students will work in each team. Display the materials that are available and encourage each team to examine the various possibilities.

If your students design their own experiments, they may discover several interesting approaches to the same problem. Encourage pupils to proceed without your help. You may suggest the following experiments to teams that are confused.

Aquarium water. To determine whether aquarium water produces the moisture, team members can half-fill a plastic cup with water from the aquarium. Tell them to place the cup of water in a plastic bag, close the bag at the top with a twistem, and put the closed bag under a light source. If moisture appears on the inside of the bag within the next day or two, the children can infer that it came from the water.

Animals. If some of your students think that the moisture was caused by the animals in the terrarium, have them put several lady beetles in a vial, cap the vial, and lay it on its side about 60 cm (2 feet) from a light source.

Because the lady beetles are small, results may vary. Assure the children that the lady beetles will not suffocate, as there is enough oxygen in a vial to support them overnight.

Remind the children to check the results of their experiments on the following day. They should then uncap the vials and return the lady beetles to the terrariums. The vials should be recapped immediately for use in later discussions.

Soil. Someone may suggest that the soil in the terrarium is a source of the moisture. The children may test this idea by removing about one-half cup of soil from their system, returning any plants and animals to the system, and placing the soil in a plastic bag. The end of the bag should be closed with a twistem. Results should be evident the next day.

Air. A child who guesses that air is a source of moisture (or who has already learned about condensation) may want to lower a plastic bag or vial into the system, close it, and put it aside overnight. Condensation may or may not occur.

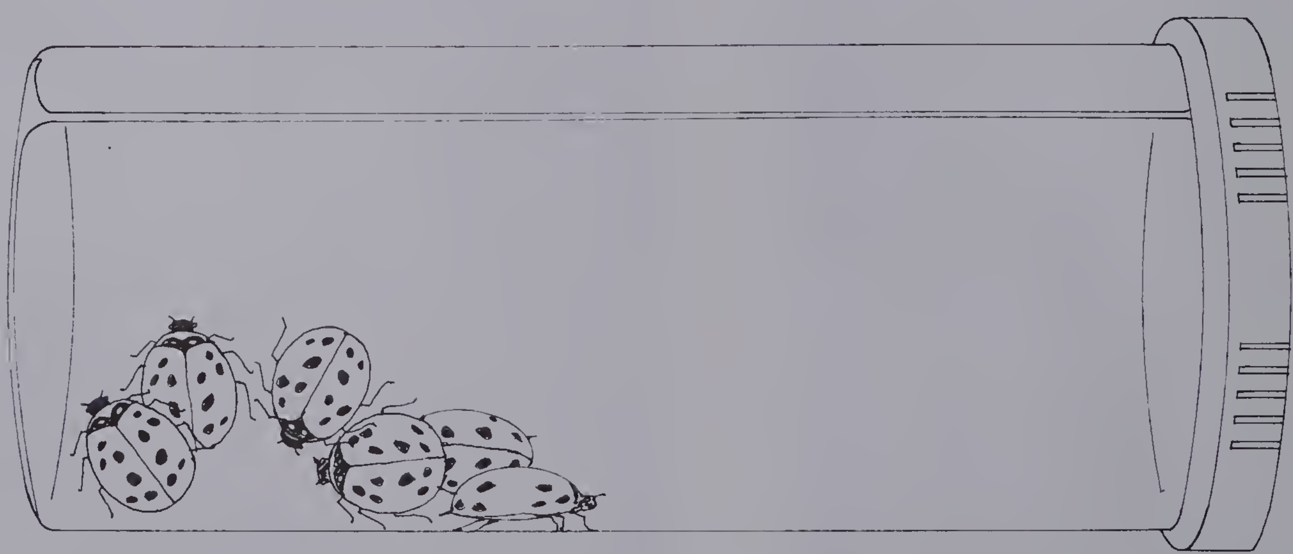


Figure 6–3. Do lady beetles produce moisture?

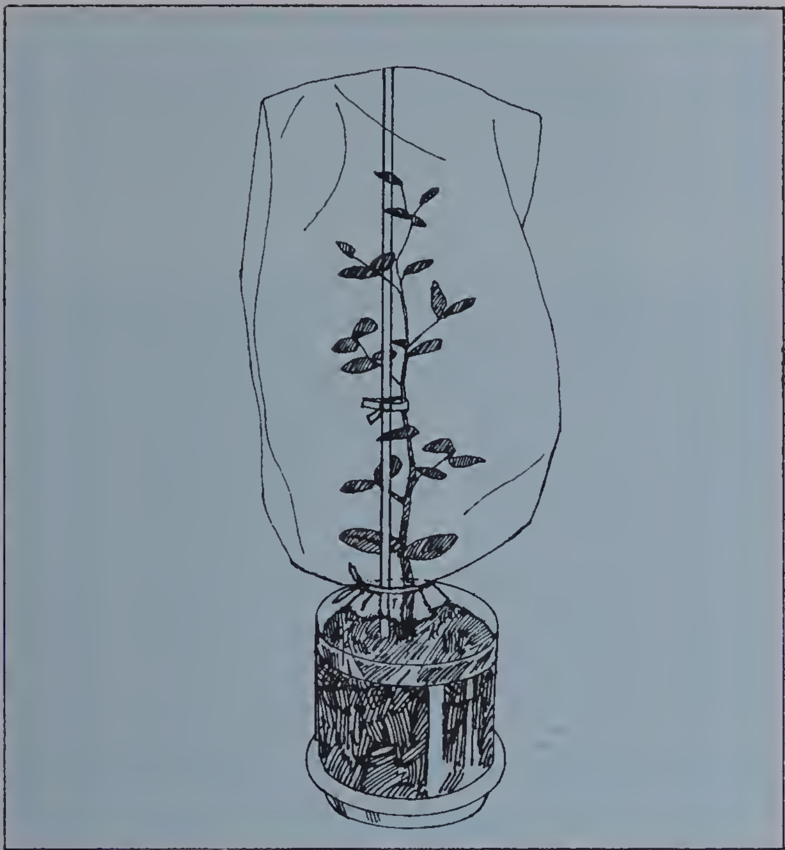


Figure 6–4. Do plants produce moisture?

Plants. If your pupils want to find out if plants give off moisture, suggest that they use the peas they planted earlier. If a plant requires support, have them loosely tie it to the stick with a twistem. Then they should cover the stick and the plant with a plastic bag and close the bag at the base of the stem with another twistem.

Storing the experiments. Student manual page 10. Each of the children should record the experiments performed by their team. The information on this page should provide feedback on how well individual students consider a question and attempt to answer it by experimentation.

The experiments should be labeled with the team members' names. Suggest that the experimental containers be placed near a light source so that the variables of light and heat can be controlled. Leave the light sources on overnight.

Discussion. On the next day, students should examine and record the results of their experiments on page 10 in their student manuals. Then ask them to group in one place all the experiments that show evidence of moisture, and group all those that do not in another location.

You may wish to have some children describe their experiments to the class. You can stimulate discussion by asking questions similar to these:

- What "objects" tested produced moisture?
- What "objects" did not seem to produce moisture?
- Which experiments resulted in the most moisture?
- Which experiments showed the least moisture?

Children generally find out that water is given off not only by the aquarium water and the soil, but also by plants and animals. Your pupils may suggest that their own bodies sweat when warm, and that they can see moisture in their breath on a cold day. Class findings should be recorded on the bottom of page 10.

Environmental factors and moisture. Most likely, certain discrepant events will occur. For example, one pea plant may give off considerable moisture and another may not. Ask the children to suggest environmental factors that might have been involved in the release of moisture.

To test their ideas, they may suggest moving experiments from light to dark areas, or to warmer or cooler places in the room. Encourage them to set up experiments that can be compared with each other.

Cleanup. Remove the plastic bags from the pea plants and save both the bags and the plants for use in Chapter 15. If eight healthy plants are not available, the children should plant pea seeds now.

10 Chapter 6

What could be a possible source of moisture in your system?

Draw or describe how you will test your idea.

What did you find out?

Observe all the experimental results and use evidence to answer these questions.

What objects produced the most moisture?

What objects produced the least moisture?

Dismantling the systems. There are no further activities dealing directly with the aquarium-terrarium systems. The systems should be dismantled unless the children wish to maintain them.

Because some of the organisms will be needed for experiments in later chapters, you will have to prepare containers in which they can live. On the day you plan to have the teams dismantle their systems, you will need two fluted containers full of aged tap water. (These will be used to store the aquatic organisms until they can be placed in larger containers.) The children can use dip nets to transfer their guppies, hornwort, daphnias, and snails to the containers.

Terrarium animals may be distributed to the children, given to another teacher in your school, used as food for frogs and lizards, or disposed of. Do not release them outdoors.

Teams should remove and discard the plants. Soil and sand may be dried for reuse or discarded. The 6-liter containers and the plastic islands should be washed thoroughly and rinsed.

GETTING READY

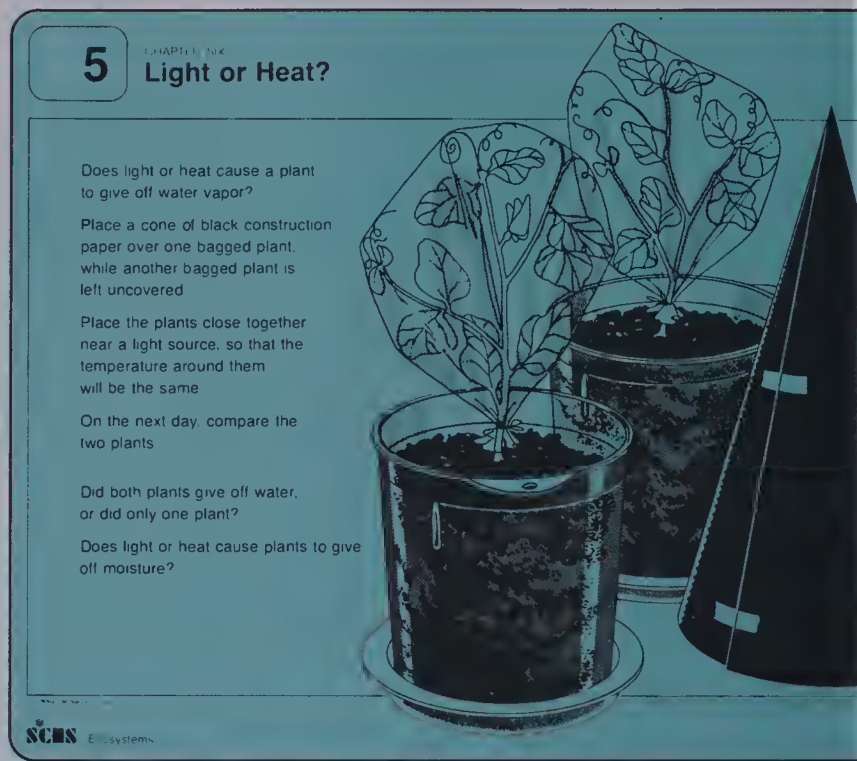
After the children have finished cleaning the equipment, fill three 6-liter containers about two-thirds full with tap water and allow them to stand overnight. On the next day, divide the aquatic organisms between two of these new aquariums and place them near a light source. Add about two crushed fish food pellets to each of the two aquariums three times weekly.

Rinse and fill the two fluted containers with tap water to maintain a supply of aged tap water.

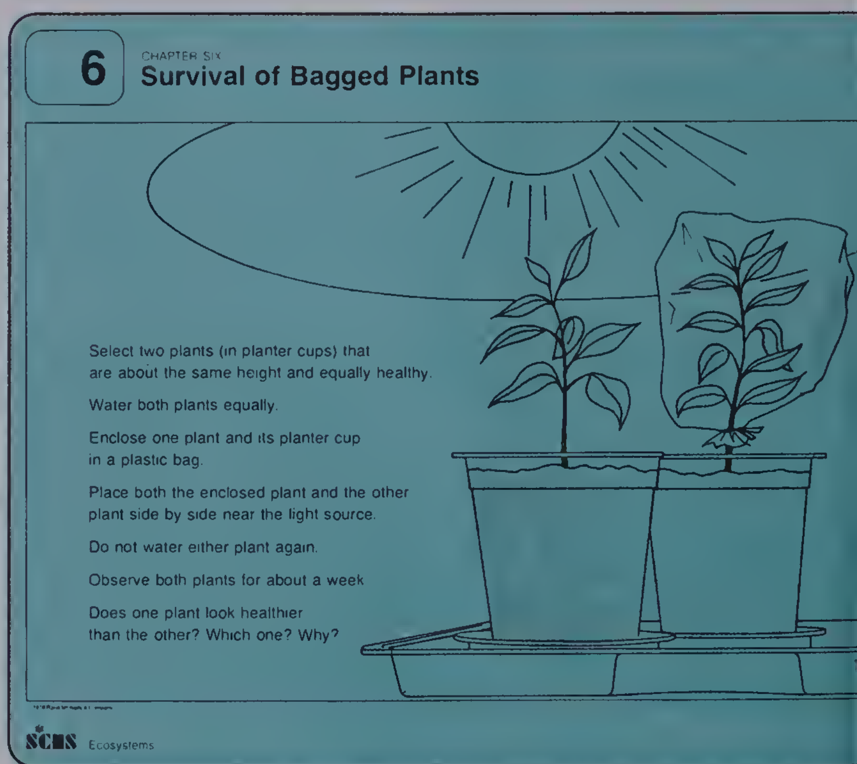
It will also be necessary to maintain an algae culture. Add two teaspoonfuls of fertilizer to the third aquarium and pour in the algae culture that was prepared in Chapter 2. Keep the culture near a light source to ensure continued algae growth. To enhance algae growth stir the culture each day or two, keeping the algae distributed uniformly throughout the culture.

EXTENDING YOUR EXPERIENCE CARDS

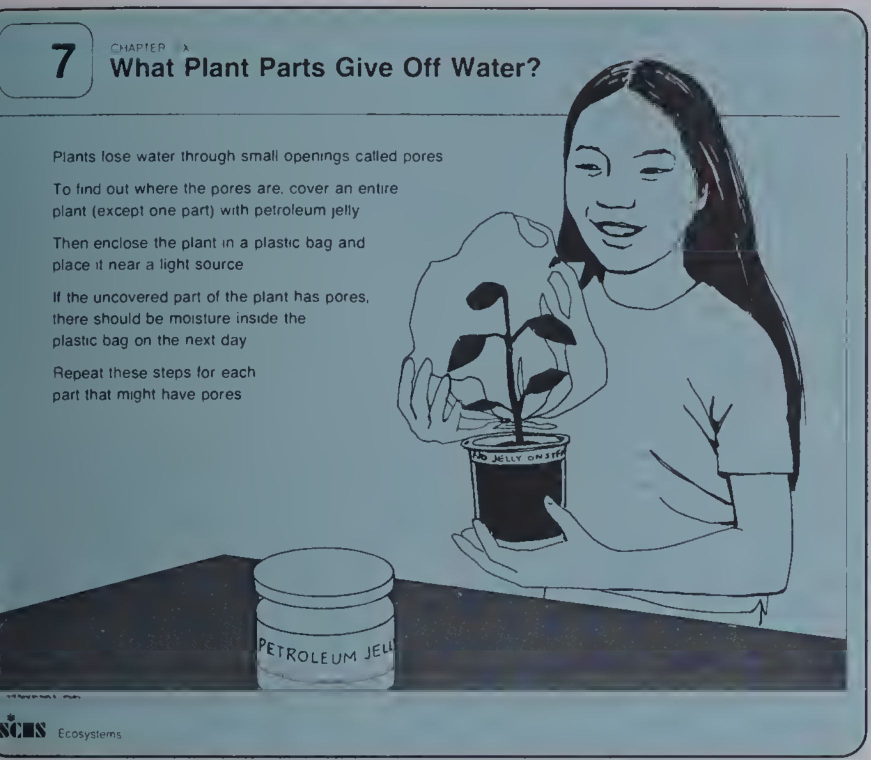
5. Light or Heat? Children experiment to find out if light or heat causes plants to give off moisture. They will need black construction paper, two plastic bags, a light source, and two growing plants.



6. Survival of Bagged Plants. In experimenting to discover if a plant and soil covered with a bag will remain healthy longer than an unbagged plant when neither plant is watered, the child will use two plants, a plastic bag, and a light source.



7. What Plant Parts Give Off Water? To discover what plant parts give off water, the student covers all parts of a plant except the suspected part with petroleum jelly. A plastic bag, a twistem, and a light source are also needed. The pores are on the stems and the undersides of the leaves.



7 Evaporation

SYNOPSIS

The children evaporate water from tumblers. They speculate on where the evaporated water went. The teacher introduces the concept evaporation.

Suggested time: *two days*

TEACHING MATERIALS

For each child:

student manual page 11

For each team of four children:

marking pencil*

Drawer 4

4 tumblers

Drawer 5

2 tumbler lids
2 thermometers

For the class:

Drawer 2

light source

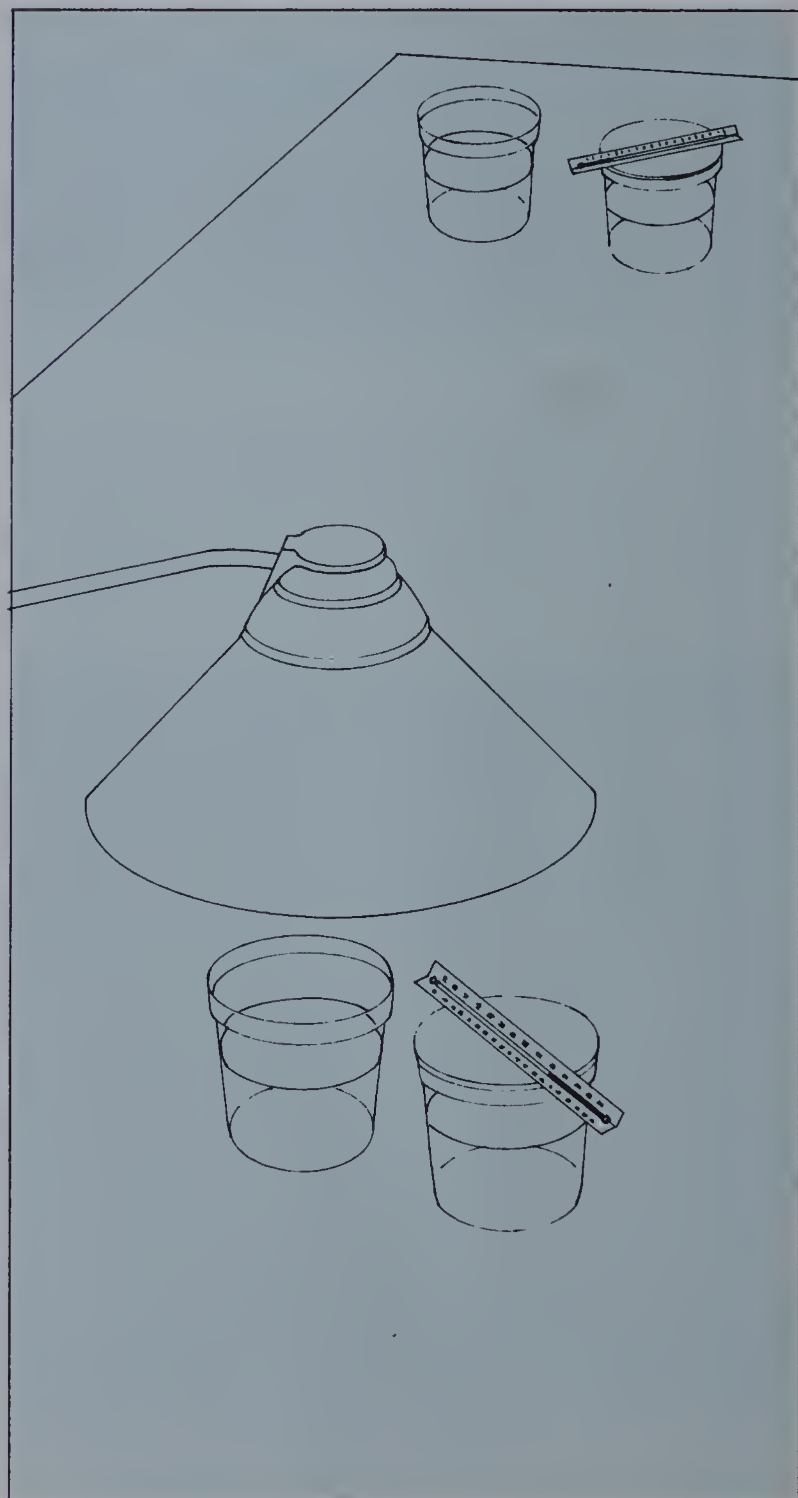
* provided by the teacher

TEACHING SUGGESTIONS

This is an exploratory and invention activity. The exploration part involves experiments with evaporation of water. The invention part occurs when the teacher introduces the term *evaporation*.

Setting up the experiment. Distribute four tumblers, two tumbler lids, and two thermometers to each team. Tell the children they are going to do another experiment with water. Ask them to half-fill all four tumblers with water and to tightly place the tumbler lids on two of the tumblers. With a marking pencil have the children mark the water line on the outside of each tumbler and label the tumblers so that the

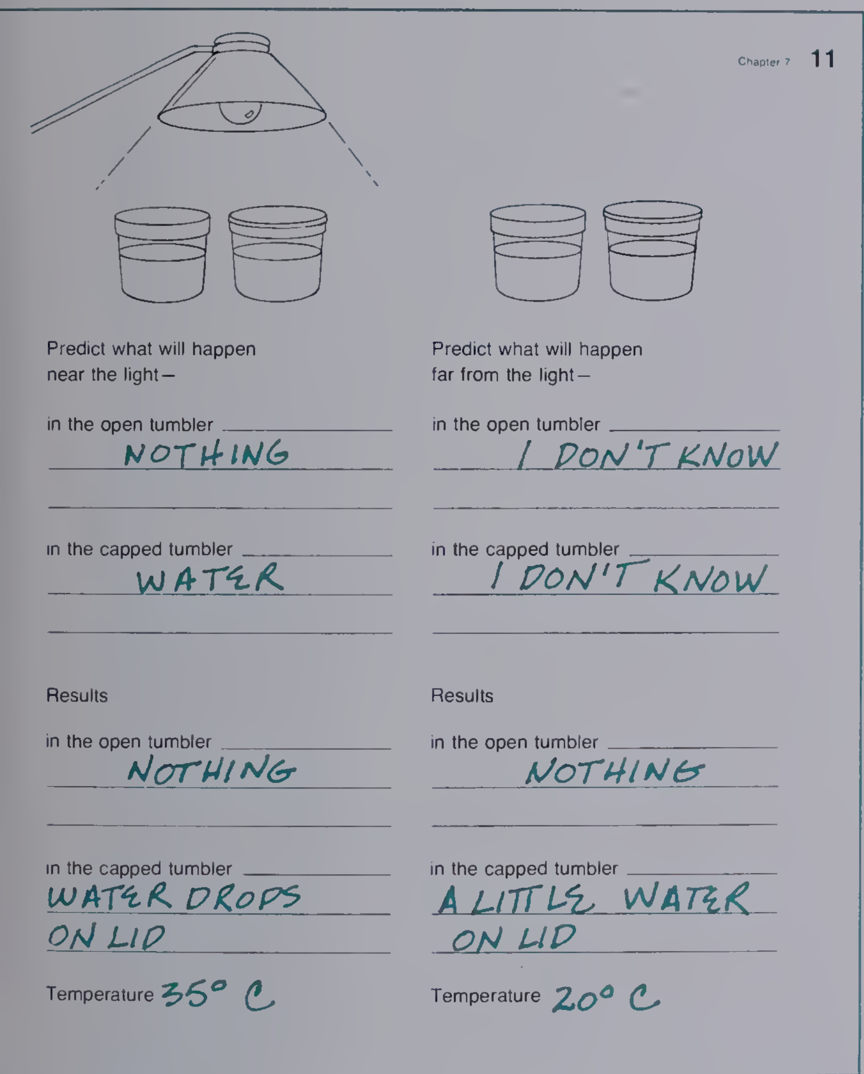
Figure 7–1. Have each team set up this experiment, sharing a light source with other teams.



teams can later identify their own tumblers. Then direct them to place one closed and one open tumbler directly under the light source. Adjust the bulb of the light source so that it is as close to the tumblers as possible. This will ensure the greatest amount of heat.

Then have each team place the other two tumblers next to each other 1 meter (3 feet) away from the light source, and lay a thermometer on each tumbler lid.

Using student manual page 11. Ask the children what they think will happen to the water in each of the four tumblers. After they have expressed their ideas, suggest that they record their predictions in their student manuals.



Chapter 7 11

Predict what will happen near the light—

in the open tumbler NOTHING

in the capped tumbler WATER

Predict what will happen far from the light—

in the open tumbler I DON'T KNOW

in the capped tumbler I DON'T KNOW

Results

in the open tumbler NOTHING

in the capped tumbler WATER DROPS ON LID

Temperature 35° C

Results

in the open tumbler NOTHING

in the capped tumbler A LITTLE WATER ON LID

Temperature 20° C

Figure 7–2. Using the student manual page.

Results. The next day permit the children to observe their tumblers, but caution them not to move their tumblers before making their observations.

- Ask them to compare the water levels in the open and closed tumblers near the light source.
- Are there drops of water inside the closed tumblers and beneath the lids?
- Then ask them to compare these tumblers with those a meter away from the light source.
- Is the water level the same or different? Are there any drops of water inside the closed tumbler away from the light source?
- Suggest that the children compare the temperatures near and away from the light source.
- Returning to student manual page 11, ask the students to record their results in the appropriate spaces.

Discussion. After the pupils have recorded their results gather them for a discussion. Use questions similar to the following in guiding the discussion:

- Did the temperature near the light source differ from that 1 meter away from it?
- Which temperature was higher?
- Did the water levels change in any of the tumblers?
- How did the water level in the open tumbler near the light source differ from that in the open tumbler 1 meter away from it?
- What might have caused this difference?
- Where did the water from the open tumbler near the light source go?
- Where did the drops of water on the sides and lid of the closed tumbler near the light source come from?
- Why did less water appear on the sides and lid of the closed tumbler away from the light source?

Inventing the concept *evaporation*. After the children have had a chance to express their ideas, tell them that water can change from a liquid to a gas, and that this gas can mix with air.

- Tell them that the change from liquid to gas is called *evaporation*. Write the term on the chalkboard.
- Then ask the children if there was any evidence of evaporation in their experiment. What was the evidence? If evaporation occurred, where did the water go?
- After the children have responded, inquire if some of the water in the closed tumbler near the light source evaporated. Did the water level in this tumbler go down as much as in the open tumbler? Why not?
- Refer again to the drops of water on the walls and under the lid of the closed tumbler. Where might these have come from?

- After the children have expressed their ideas, do not pursue the matter further. The question is the basis for the activities in the next chapter.
- Refer again to the different temperatures of the tumblers near and away from the light source. Was there any evidence of evaporation in the tumblers away from the light source?
- If so, was the evaporation as much as in the tumblers near the light source?
- On the basis of the children's comparison of amounts of evaporation and temperature, ask how temperature may affect evaporation.

Cleanup. Empty all the tumblers, remove the water level marks, air dry, and replace the tumblers in the kit.

GETTING READY

You will need ice cubes for Chapter 8. Plan to bring them to school or arrange to get some from the cafeteria.

8 Condensation

SYNOPSIS

The children observe moisture on the outside surfaces of vials containing ice water.

They infer that this moisture comes from the air. The term* condensation *is introduced.

Suggested time: ***one class session***

TEACHING MATERIALS

For each child:

student manual pages 12 and 13

For each team of two children:

Drawer 4

1 vial

For the class:

tin can (optional)*
pocket mirror (optional)*
ice*
refrigerator (optional)*

Drawer 3

baster
plastic bag (optional)

Drawer 4

pitcher
1 tumbler (optional)
1 vial (optional)

* provided by the teacher

BACKGROUND INFORMATION

The appearance of moisture on the inside of window glass or on the outside of a tumbler of cold beverage is commonly observed, but its cause is often not understood. The air around us contains water vapor, and when we use the term *humidity* we are talking about the amount of moisture in the air. Warm air can hold more water vapor than cold air. Thus, when warm air is cooled by contact with a cool surface, water vapor in the air condenses and forms droplets of liquid on the cool surface.

The success of this activity depends on whether your classroom air contains a certain amount of moisture; therefore you should try the vial experiment in advance. If moisture does not form on the outside of the vial, the air in your room is dry; in that case try the experiment early in the morning, when humidity is likely to be higher. If you still get no condensation, use a small tin can, with the label removed, instead of the vial. Moisture usually condenses readily on metal. If neither method works, try exhaling on the side of the vial or can before and after the ice water has been added in order to illustrate the effect of temperature.

ADVANCE PREPARATION

Fill a pitcher with ice water. If you wish to use a mirror in this activity, set it on ice in a plastic cup.

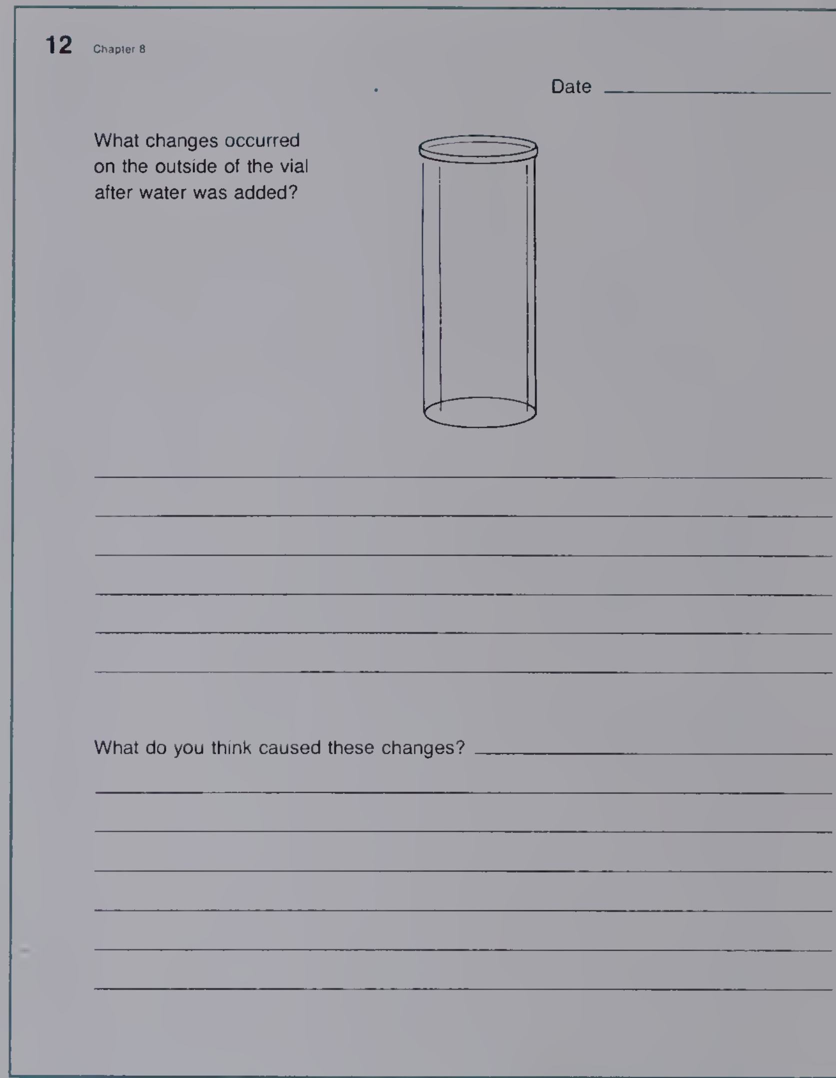
TEACHING SUGGESTIONS

This is an exploratory and invention activity. The exploratory part includes the children's observation of water droplets appearing on a cold surface. The invention part consists of your introduction of the term *condensation* to explain the appearance of the water droplets.

Figure 8-1. Condensation on a metal can.

Using student manual page 12. Distribute a vial to each team and then ask the children to turn to student manual page 12. Tell them that you will pour water into the vial and that they can describe in the manual what they observe. Do not give them any further clues. Using the baster, fill each vial half full with ice water.

Permit the children to manipulate the vials as they wish, and observe them while they make and record their observations.


12 Chapter 8

Date ________

What changes occurred on the outside of the vial after water was added?

____

What do you think caused these changes? ____

Figure 8–1. Adding ice water to one team's vial.

Discussion. Ask the children where they think the moisture that appeared on the vials came from. Some of them may claim that it came from the water inside the vials. Ask these children how they might test this idea.

They may suggest that the vial be capped immediately after the water has been poured into it. Carry out this procedure, and when moisture appears again, it should be clear that it did not come from the water inside.

If you prefer to use another method, place an empty, dry vial inside a plastic bag and put the bagged vial inside a refrigerator for about twenty minutes. When you remove the cold vial from the bag and place it in the room, moisture is likely to appear. From these experiments the children should realize that the moisture was in the air outside the vial.

Ask the children for other examples of moisture forming on surfaces. If they do not volunteer any ideas, have someone exhale onto a cold pocket mirror or windowpane and report what happens.

After the children have agreed that the water on the outside of the vials came from the air, tell them that when water changes from a gaseous form (in air) to a liquid form, the water condenses, and that the process is called *condensation*. Write the terms condensation and evaporation on the chalkboard and ask the children to use the words to describe what happened when you put ice water in their vials.

Using student manual page 13. At this point, refer your students to the manual to answer the questions.

Remind the children that you poured ice water into the vials on which the water condensed. Then ask them whether the vial with ice water was cooler or warmer than the air from which the water condensed. If the children exhaled on a mirror and produced condensation, ask them if the mirror was cooler or warmer than their exhaled breath.

Refer to the experiments on evaporation and ask the children what temperature conditions were necessary for evaporation to occur.

Cleanup. The vials should be emptied, allowed to dry, and put away.

Chapter 8 13

Brain Teaser

One day Mrs. Grant's class noticed moisture on the inside of the classroom windows. Where did the moisture come from?

Do you think the temperature outside the classroom was higher or lower than the temperature inside?

The students also noticed there was no moisture on the classroom walls. Why do you think the moisture was on the windows and not on the walls?

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the evaporation and condensation of water, turn to page 96 of the evaluation section at the back of the guide.

9 "Inventing" the Water Cycle

SYNOPSIS

The children try to evaporate water at one end of a container and condense it at the opposite end.

The term **water cycle** *is introduced.*

The water cycle the children observe is compared to the water cycle outdoors.

Suggested time: *two days*

TEACHING MATERIALS

For each child:

student manual pages 14–17

For each team of two children:

Drawer 3

1 label

Drawer 4

1 tumbler

Drawer 5

2 fluted containers

For the class:

ice (optional)*
water*
masking tape*

Drawer 2

2 light sources

Drawer 4

pitcher

Drawer 5

thermometers

* provided by the teacher

TEACHING SUGGESTIONS

This is a discovery and invention activity. The children experiment to discover the conditions that cause evaporation and condensation of water. After this, you "invent" the water cycle.

Designing the experiments. Remind the children of the experiments they did on evaporation and condensation of water. Discuss with them the temperature conditions that cause evaporation and those that cause condensation. Then show them the equipment listed under "Teaching Materials" and ask them if they can think of a way to get a tumblerful of water to evaporate and to condense inside two fluted containers.

Allow time for the children to discuss how they might do the experiment. Let teams pick up the equipment and begin their experiments as soon as they have a few ideas. Some may wish to use a thermometer to measure the temperature on various surfaces of the container. Some children may want to use ice to produce a greater temperature range within the container. Suggest that the fluted containers (one upside down on top of the other) be taped shut with masking tape. Tell the children to label their systems with their names.

Using student manual page 14. Each child should make a record of his or her team's experimental setup at the top of the page. Even if you think that the way that the children have planned their experiments will not produce "desired" results, let them realize their errors on their own. Some children can verbalize how water evaporates and condenses, but cannot bring it about operationally. The errors they make will provide you with feedback. For example, a child who places a heat source at one end of the container and the water at the other does not understand the conditions necessary for evaporation.

Observing and discussing results. Have the children examine their experiments the next day. Give them a few minutes to study their experiments and to determine if the results they obtained were what they expected. They should record their results on page 14 in their manuals. Ask a few children to describe how they set up their systems—they may diagram these on the chalkboard—and then describe their results.

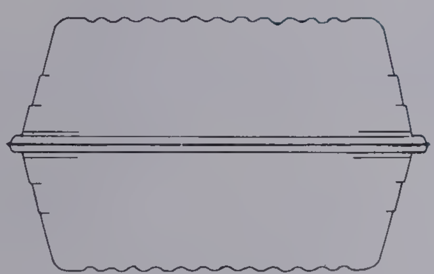
Invite the pupils to comment on the various procedures that were tried and the differences in results. Some students may not yet realize that heat is required to evaporate water and that the surface on which the droplets form must be cool. If some teams wish to repeat their experiments with modifications, you may wish to allow them to do so before proceeding to the invention of the water cycle. Possibly the whole class would like to try again.

Figure 9–1. For good results, the light should be near the tumbler.

14 Chapter 9

Set up your equipment so that water condenses at one end.

Draw the positions of the lamp, cup, and any other materials you use.



Describe what happened. What do you think caused the result?

"Inventing" *water cycle.* Draw the experimental setup shown in the illustration and review with the children what happened to the water in their experiments. Tell them that when water evaporates and then condenses, we call this a *water cycle*. The water cycle idea is a way of thinking about water evaporating and condensing over and over again.

Ask the students for examples of the water cycle outdoors. You might ask what happens to the local rainfall once it reaches the ground. The children may say that the rainwater flows into lakes or the ocean and finally evaporates into the air; that it soaks into the soil and then evaporates into the air; or that it is absorbed by plants and animals and then is returned to the air. Follow through with each example until the water condenses and again falls to the ground.

To emphasize the importance of the water cycle, ask some of the following questions:

- How do organisms living far from a body of water obtain the moisture they need?
- How does the water travel there?
- Could the water cycle exist if there were no organisms on Earth?
- Could land organisms exist if there were no water cycle?

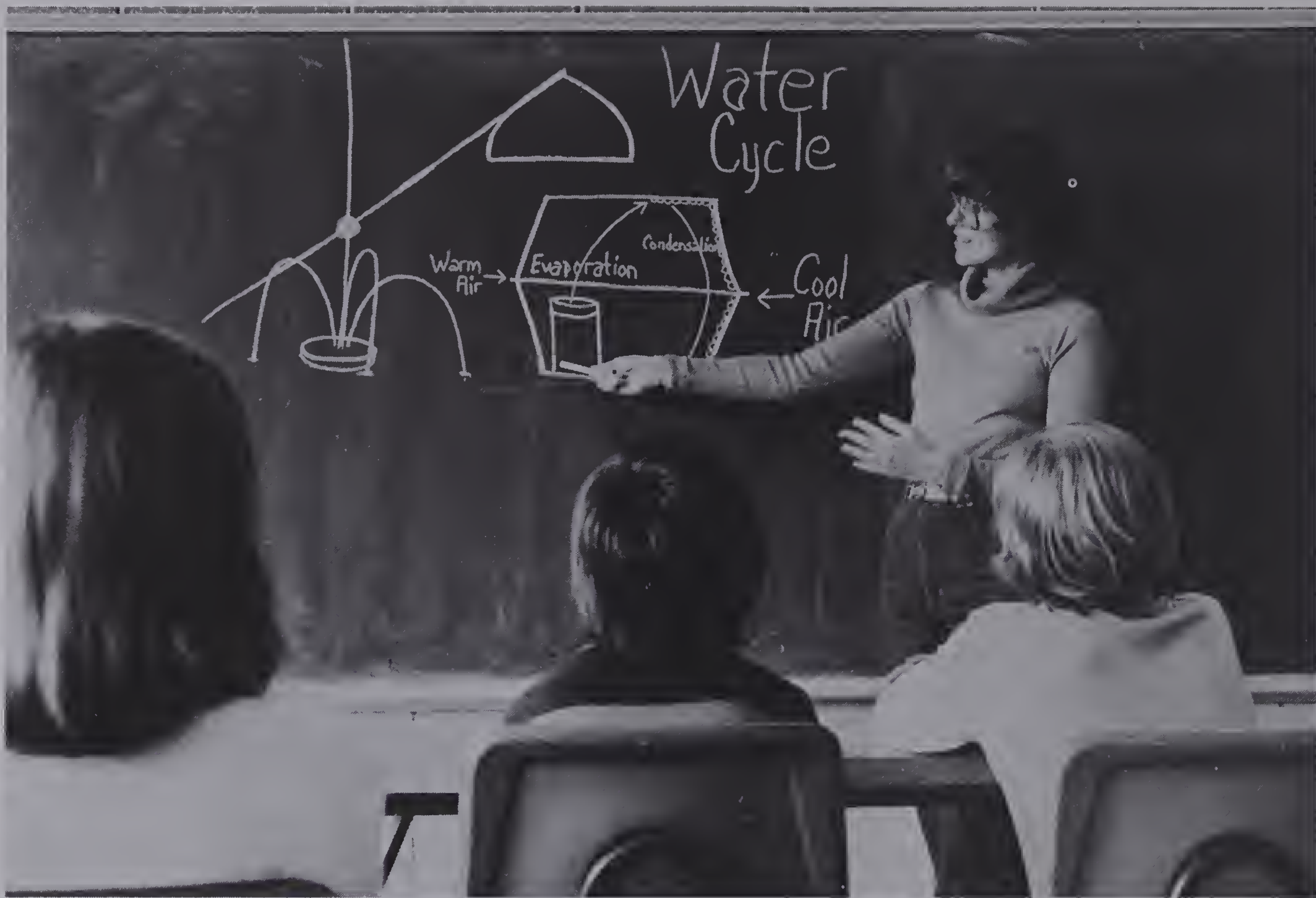


Figure 9–2. "Inventing" water cycle.

Feedback. Student manual pages 15–17. Your pupils' responses to the question on page 15 should supply you with feedback concerning their understanding of the role temperature plays in the water cycle. If some children have trouble explaining the disappearance of fog, you might wish to have them repeat some of the water-cycle activities in this and previous chapters. (Fog consists of visible, minute globules of water in the air. As the temperature of the air rises because of the sun, the globules of water evaporate to form invisible water vapor.)

On pages 16 and 17 the children apply their understanding of the water cycle to a practical situation. Encourage interested students to try out some of their solutions to Doc Gregory's problem. You might suggest that fluted containers could be used to construct a "model" greenhouse.

Cleanup. Have the children take apart the experiments and wash and dry the containers.

Chapter 9 1

Brain Teaser

8:00 A.M. 12:00 Noon

Early morning fog often disappears before noon.
Why do you think this happens?

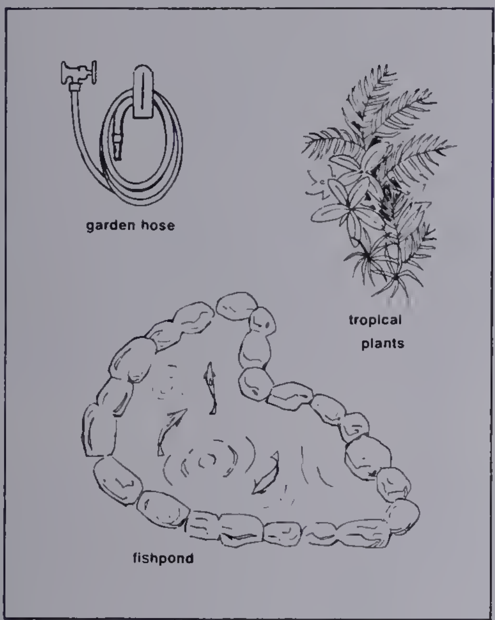
16 Chapter 9

Brain Teaser

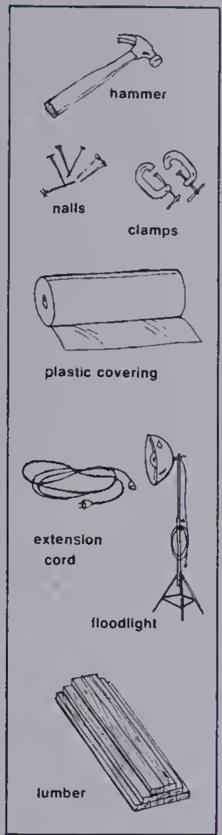
Doc Gregory raises tropical plants as a hobby. These plants require a constant supply of moisture, but they will die if they are over-watered.

Doc Gregory will have to leave her greenhouse for two weeks while she attends a convention. There is no one to water the plants for her.

Greenhouse



Shed



Chapter 9 17

In the space below, draw and describe how Doc Gregory could use the materials she has available to insure that the plants will get the moisture they need while she is away.

EXTENDING YOUR EXPERIENCE CARD

8. Does Temperature Make a Difference? Children experiment to discover whether temperature affects water evaporation and condensation. They will need two vials, two thermometers, a light source, and a refrigerator.

8 CHAPTER NINE

Does Temperature Make a Difference?

Fill two vials with water. Place a thermometer in each vial.

Lower the light source so that one of the vials can be placed directly against the lighted bulb.

Place the other vial someplace on the other side of the room, away from the light source.

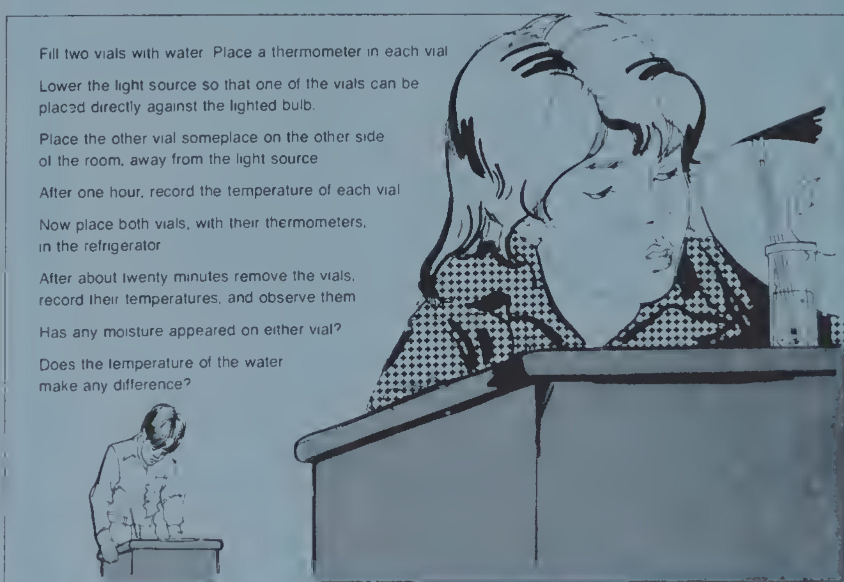
After one hour, record the temperature of each vial.

Now place both vials, with their thermometers, in the refrigerator.

After about twenty minutes remove the vials, record their temperatures, and observe them.

Has any moisture appeared on either vial?

Does the temperature of the water make any difference?

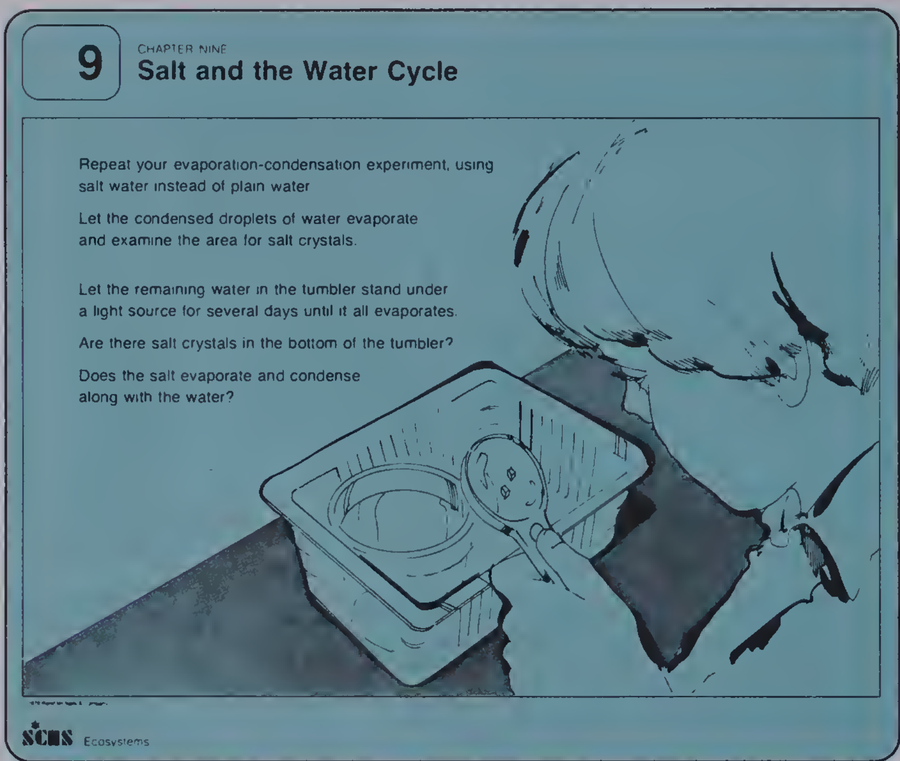


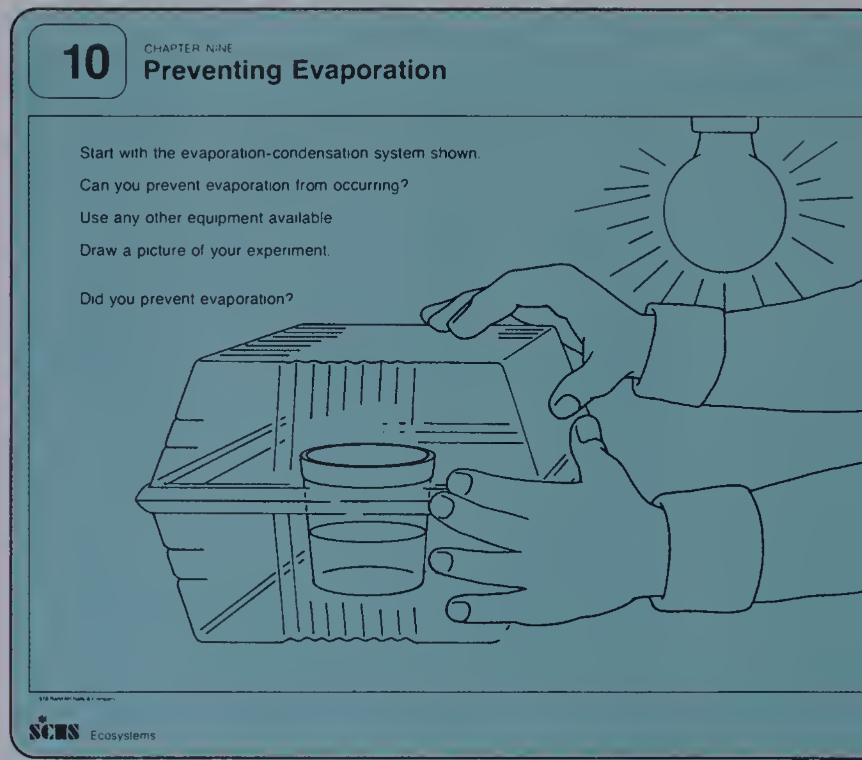
SCIS

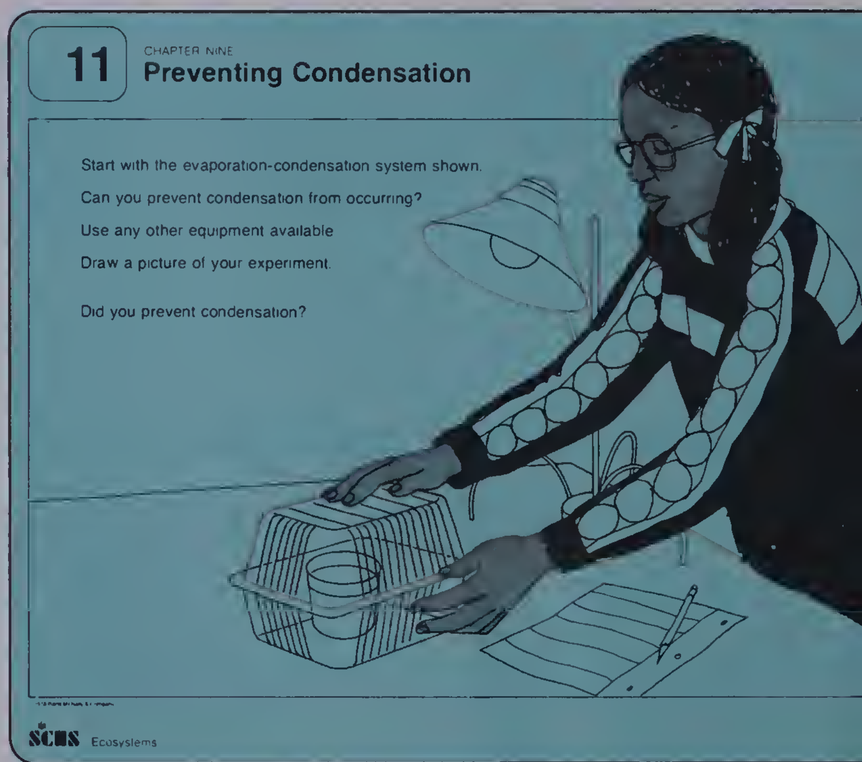
9. Salt and the Water Cycle. Children experiment to see if salt in water will evaporate along with the water. They will need salt, two fluted containers, masking tape, and a tumbler.

10. Preventing Evaporation. Starting with the water evaporation and condensation equipment (two fluted containers, a tumbler, and a light source) plus anything else they need, students make whatever changes they can think of to prevent evaporation.

11. Preventing Condensation. Starting with water evaporation–condensation equipment (two fluted containers, a tumbler, and a light source) plus anything else they need, students make whatever changes they can think of to prevent condensation.

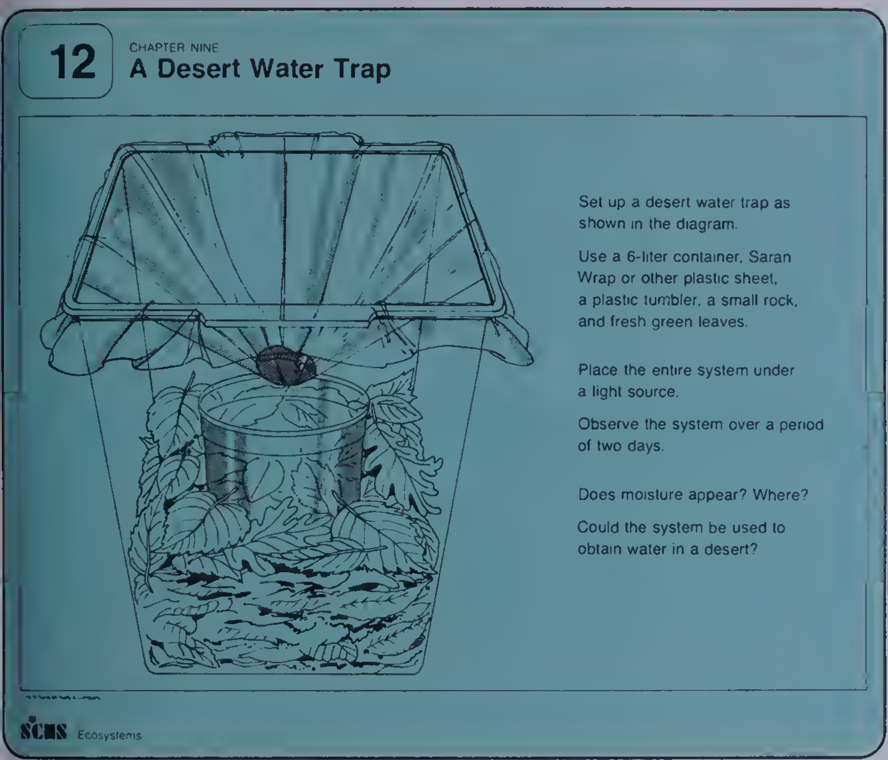


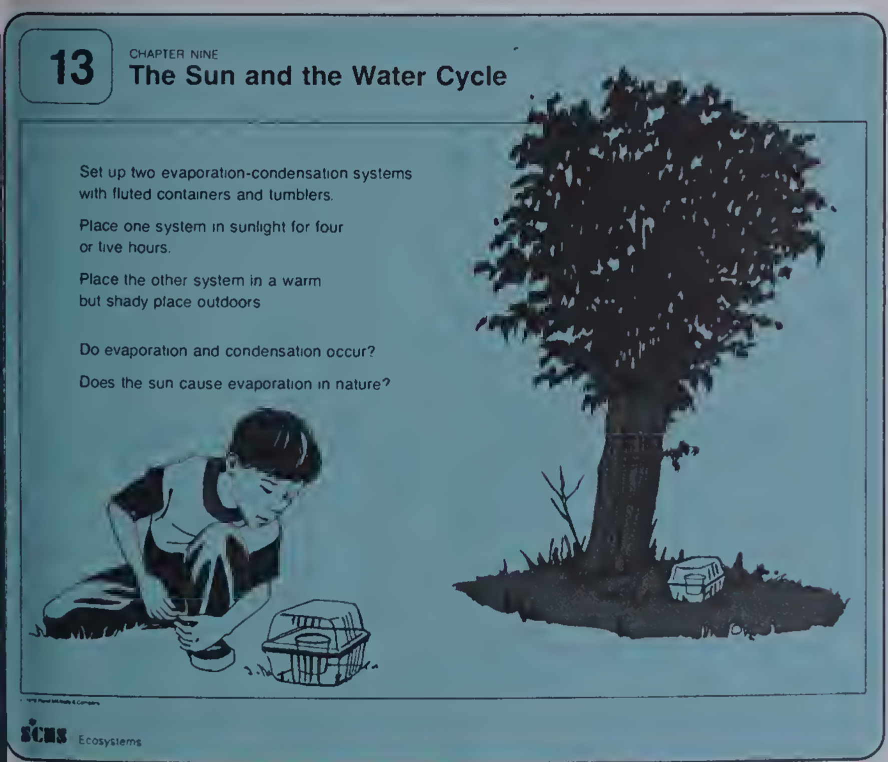




12. A Desert Water Trap. Students construct a system that uses fresh green leaves and sunlight to collect water. A 6-liter container or box, a plastic sheet, tumbler, a small rock, and some fresh green leaves are used in this activity.

13. The Sun and the Water Cycle. Students place evaporation-condensation systems outdoors. Four fluted containers, masking tape, and two tumblers are required for the two setups.





Extending Your Experience cards 1–13 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the water cycle, turn to page 97 of the evaluation section at the back of the guide.

Part Three

The Oxygen–Carbon Dioxide Cycle

OBJECTIVES

To use data to verify hypotheses about gases that plants and animals produce and use

To use the term oxygen-carbon dioxide cycle to refer to the exchange of gases between organisms and their environment.

BACKGROUND INFORMATION

By the time children reach the sixth grade, many of them know that green plants take in carbon dioxide and give off oxygen, and that animals carry out the reverse process. This knowledge is seldom based on firsthand observation or on experiments. Otherwise, they might also be aware that such a statement is an oversimplification.

In the presence of light, green plants do take in carbon dioxide and give off oxygen. The carbon dioxide is used in the food-making process called photosynthesis, of which oxygen is a by-product. In the dark, however, plants (like animals) use oxygen and give off carbon dioxide.

Photosynthesis provides the food and oxygen necessary for the life processes of plants and animals. As a result of these life processes, carbon dioxide is given off to the air, where it becomes available for plants to use again in photosynthesis. As a consequence, the world of living things exists as an interdependent system: plants depend on animals for part of their continuing supply of carbon dioxide, and animals depend on plants for food and oxygen.

The decomposers—molds and bacteria—present another aspect of this interdependent system. As they digest dead organisms and organic wastes, decomposers release minerals, gases, and water, which plants take in and use.

Figure III–1. An experiment with BTB.

Bromothymol blue. Bromothymol blue (BTB) is a chemical indicator that changes color when it interacts with acids such as vinegar and citric acid. A BTB and tap water solution is usually blue; if this solution is made increasingly acid, the color will change through shades of green to yellow. Children who have used the SCIIS *Interaction and Systems* or *Subsystems and Variables* units will have observed the interaction of acids and BTB. In this unit BTB is used as an indicator for the presence of carbon dioxide. This is the only gas normally found in our atmosphere that will interact with BTB.

Human breath contains a small quantity of carbon dioxide. As breath is bubbled through water, some of the gas remains, making an acid solution. The more carbon dioxide in the solution, the more acid it becomes. The concentration of acid in a BTB solution determines the degree of color change. The amount of BTB present affects only the intensity of the color.

Controlled experiments. A controlled experiment consists of at least two setups that are identical in all ways except one. Any difference in the results of the experiment can be attributed to the one difference in variables between the two setups.

An example occurs in Chapter 11, where students attempt to determine what caused yellow BTB solutions in open cups to turn blue after being kept overnight. To determine if light is the variable that caused the color change, a team prepares two vials of yellow BTB solution. Both vials are capped to prevent any gas from entering or leaving, and they are placed together near a light source so that both have the same temperature. As a control, one vial is covered so no light could reach it.

In this experiment the only difference between the two vials is the presence of light. If the BTB solution in one vial changes to blue after a certain time, but in the other vial it remains yellow, you might conclude that light is a factor in the color change. However, if both solutions remain yellow, you would conclude that light is not a factor. Something else, as yet undiscovered, causes the yellow BTB solution to turn blue.

Additional controlled experiments would have to be carried out to test other possible causes. In each case, all of the variables except one would be kept the same.

OVERVIEW

In Chapter 10, "Breath and BTB," students begin their study of the interrelationships of gases and organisms by exhaling through BTB solutions. They are told that the color change observed is the result of an interaction between BTB and carbon dioxide. The solutions that have changed color are left overnight. In Chapter 11, "Where Did the Yellow Go?" the children propose hypotheses to account for the color reversal that takes place. In Chapter 12, "Soda Water and BTB," they obtain evidence that a color change from yellow to blue BTB is due to something leaving the solution rather than something entering it.

In Chapter 13, "Exchange of Gases in Organisms," the students explain their understanding of the interactions of carbon dioxide and oxygen between plants and animals. They begin their investigations in Chapter 13 by carrying out tests on aquatic plants and animals in light. In Chapter 14, " 'Inventing' the Oxygen–Carbon Dioxide Cycle," they continue their investigations on plants and animals kept in darkness. You introduce the oxygen–carbon dioxide cycle. Further experience with the oxygen–carbon dioxide cycle is provided in Chapter 15, "Land Plants and Gases," when children experiment with land plants.

GETTING READY

The success of the BTB activities in this Part depends on the acidity of your tap water. Test your tap water by adding about twelve drops of BTB to a cup half full of water and stir. If the water becomes blue, blow into it through a straw. If the color changes to green and then to yellow within a minute or so, the water is satisfactory and needs no adjustment.

If the water does not change in color after you have blown into it, it is too alkaline. In that case, fill each of 3 fluted containers to within 1 cm (½ in) of the top with tap water. Add about thirty drops of BTB and stir. Slowly add drops of vinegar to the blue solution, stirring after each drop. When the color changes to green, stop adding vinegar.

Now slowly add ammonia, stirring after each drop. Stop when the solution turns blue. To test some of this blue solution, pour a little into a cup and blow through it with a straw. It should turn yellow in less than a minute. This blue solution can be used for the experiments.

10 Breath and BTB

SYNOPSIS

Children blow through solutions of BTB and observe that they change from blue to green or yellow.

You introduce the term **carbon dioxide gas** *and explain that when this gas interacts with BTB the color of the solution changes.*

The students identify **variables** *that affect the results of this experiment.*

Suggested time: *less than one class session*

TEACHING MATERIALS

For each child:

Drawer 3

1 straw

Drawer 4

1 tumbler

For the class:

Drawer 5

3 bottles BTB
1 bottle vinegar
1 bottle ammonia
3 fluted containers

CAUTION
BTB is nontoxic, but it can stain clothing. Therefore, caution the children to handle it with care.

ADVANCE PREPARATION

Fill the fluted containers with water for the children to use when making BTB solutions. If you found your water to be unsatisfactory, prepare BTB solutions according to directions on page 44.

TEACHING SUGGESTIONS

This is an exploratory and invention activity. The children explore the effects of blowing their breath through BTB solution. You then introduce the term carbon dioxide and explain that BTB can be used to test for the presence of carbon dioxide.

To introduce this activity, explain that over the next few weeks the class will experiment with gases taken in and given off by organisms. Ask the children if they know of a test to identify the gases. If they have had experience with BTB in previous SCIIS units, they may suggest repeating those activities.

The test. Explain that each child should half-fill a tumbler with water and add about twelve drops of BTB to it (or obtain one-half cup of the solution you pre-

Figure 10–1. Producing a change in the BTB solution.

pared). Because the angle at which the bottle is held affects the size of the drops, the blueness of the children's solutions may vary. Rather than trying to perfect the children's technique, let this difference be a variable that the children can identify later.

Tell the children to exhale through the straws so their breath bubbles slowly and gently through the BTB solution. Ask them to stop blowing when they see evidence of change, but do not tell them what to expect.

When the children see the color change from blue to green, ask if the solution will continue to change color or what will happen if they continue to blow. Will the solution turn a different color if it is stirred while they are exhaling into it? Whatever they reply, have them try it.

When most of the children's solutions have turned yellow, tell them that they will examine these later to see if any further changes occur. The children should write their names on the frosted rims of the tumblers and store them where they can be easily seen.

Carbon dioxide gas. Have the children describe in more detail the color changes that occurred: what colors the solutions became, and if the changes were gradual or abrupt. Then ask them what might have caused this color change.

If the children do not suggest it, explain that *carbon dioxide,* one of several gases in their breath, interacted with the BTB solution to bring about the color change. Write the term carbon dioxide on the chalkboard and, if you wish, introduce the chemist's shorthand expression for this: CO_2.

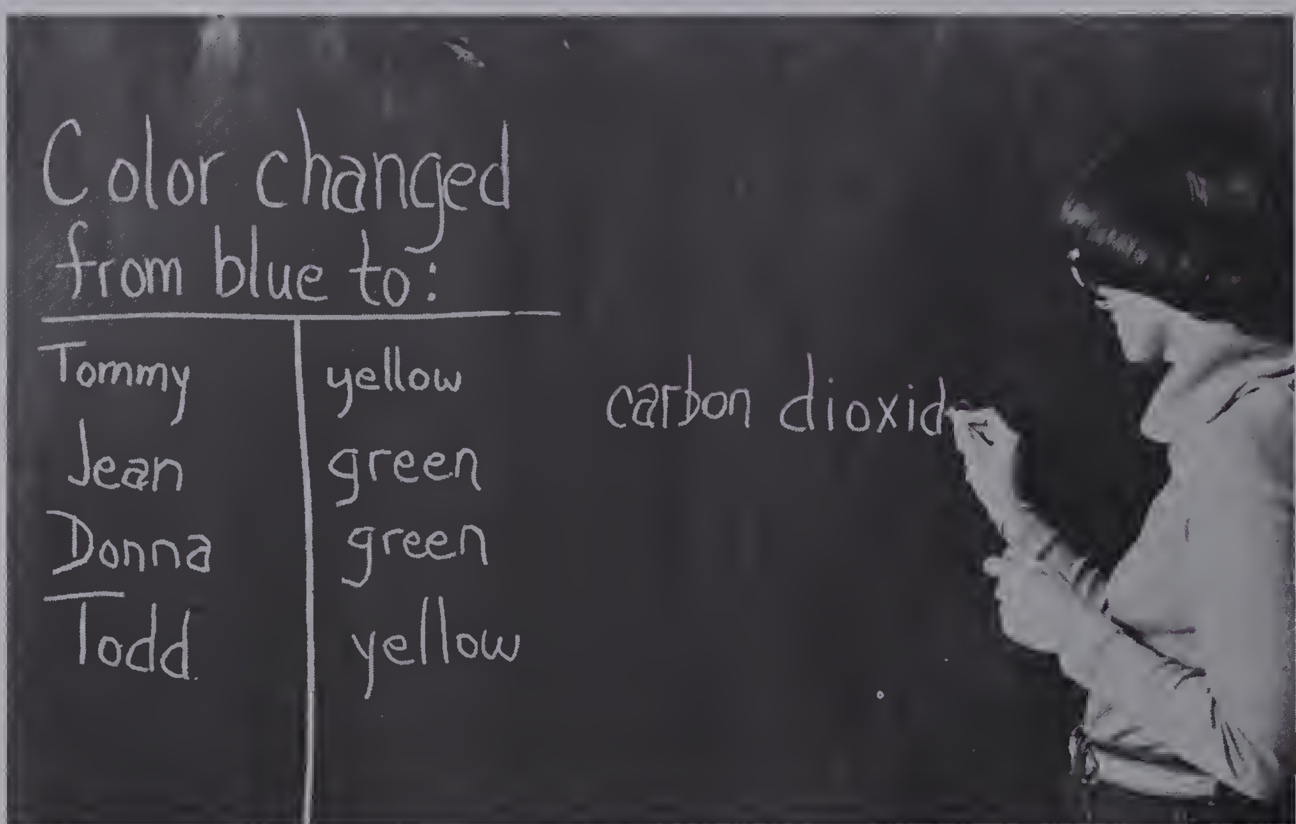
Explain that they will be using the BTB to indicate the presence of carbon dioxide in later experiments. Add that carbon dioxide is the only gas normally present in our atmosphere that will interact with BTB to produce the color changes they have observed. Tell them that carbon dioxide makes an acid in water and that BTB indicates the presence of the acid. If a little carbon dioxide, and hence some acid, is in water, BTB becomes green. If the water contains much carbon dioxide, BTB becomes yellow.

Next, ask the children what would happen if they blew into plain water and then added blue BTB. If any children wish to try the experiment, let them use extra tumblers from the kit.

Discussing variables. Call the students' attention to the varying shades of green and yellow, and ask what might have caused these differences. The children are likely to mention the amounts of breath exhaled, the amounts of time during which they exhaled, differing shades of the solutions at the start of the activity, "bad breath," and so on. Remind them that these differences are called *variables.*

In this discussion you can review the idea of a controlled experiment. As your pupils discuss the variables, ask them to suggest ways of controlling the experiment so that only one variable is tested at a time.

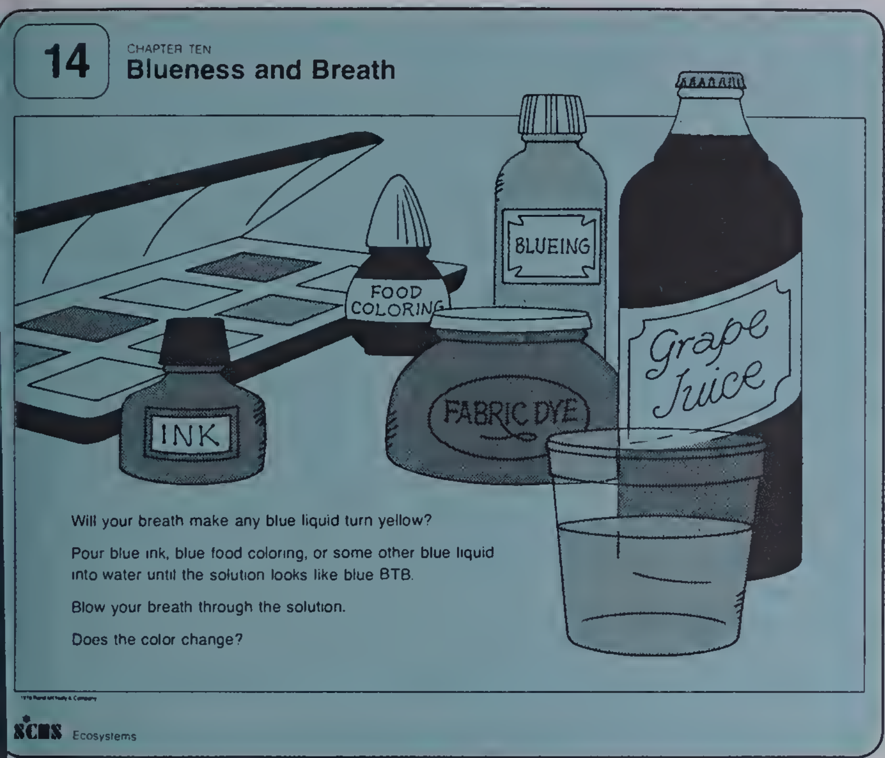
Figure 10–2. Identifying carbon dioxide as bringing about the color change.



Cleanup. The straws may be discarded. Any tumblers used in the second experiment should be rinsed, dried, and stored.

EXTENDING YOUR EXPERIENCE CARDS

14. Blueness and Breath. The children blow their breath through blue ink , blue food coloring, or other common blue dyes to find out if the liquid will change color. Blue dye, a tumbler, and a straw are needed.


14
CHAPTER TEN
Blueness and Breath

Will your breath make any blue liquid turn yellow?

Pour blue ink, blue food coloring, or some other blue liquid into water until the solution looks like blue BTB.

Blow your breath through the solution.

Does the color change?

SCIS Ecosystems

GETTING READY

You will need at least eight pea plants in Chapter 15. If necessary have children plant pea seeds at this time to make sure you have healthy plants.

11 Where Did the Yellow Go?

SYNOPSIS

The children observe that the green or yellow BTB solutions left overnight have turned blue.

They design and carry out experiments to determine the cause of the color change.

Suggested time: ***two class sessions***

TEACHING MATERIALS

For each child:

student manual page 18

For each team of two children:

2 tumblers BTB solution (prepared in Chapter 10)

Drawer 3

1 straw

Drawer 4

2 vials with caps

For the class:

Drawer 3

adhesive dots (green and yellow)

Drawer 5

3 bottles BTB

TEACHING SUGGESTIONS

This is an exploratory activity. The children experiment to find out the cause of the change in the color of the BTB solution.

A change in color. Children in our trial classrooms have been surprised when they observe that the solutions left overnight have changed color. Encourage your children to speculate about what might have caused the color change.

Some children may believe that the change resulted from time or temperature, but others may believe that carbon dioxide left the solution. Someone is almost certain to suggest that oxygen entered the solution and made the BTB blue. List the hypotheses on the chalkboard as the children give them.

Planning the experiment. Student manual page 18. Tell the children they may work in pairs to test their hypotheses, each team designing its own experiments. Suggest that all conditions be kept alike, except the one variable to be tested (such as temperature or time). The students will probably suggest using fresh BTB solutions. In that case, each team may discard the solutions prepared in Chapter 10 and make new ones. The team members should state their hypotheses and describe the experiment in their manuals.

Suggested experiments. Children are likely to suggest that the color of the BTB solution returned to blue because something entered or left the solution. They can check this hypothesis by sealing the solutions in containers. Children may blow through BTB solutions in plastic cups until the solutions are green or yellow. Since the plastic cups are difficult to seal, the experiment may be done with vials. Each team can use its solution to fill two vials; one is capped and the other uncapped. (No air space should be left in the capped vial.)

Should the children think that temperature was responsible for turning the BTB solution blue, both vials should be capped: one may be left in the room, and the other placed in a refrigerator or in a place warmer than the classroom. If light is being tested, one of the capped vials can be put in the light and the other in the dark, but both at the same temperature.

All vials should be labeled with the names of the team members and a green or yellow dot to record the color of the BTB solution after the children have blown through it.

Observing the results. Student manual page 18. During the next science period, have the children observe their experiments and record the results in the student manual. Then ask them to group those sets of vials in which the contents of one remained green or yellow and the other returned to blue. In a different area they may group those sets in which the liquid in

Figure 11–1. The label color for each vial should indicate the solution color.

18 Chapter 11

What changes did you observe in the BTB solution after it stood overnight?

What might have caused this to happen?

Plan an experiment to test your ideas. Draw or describe your experiment.

What were your results?

both vials returned to blue, or both remained green or yellow.

Have several teams explain their experiments to the class. Ask the children why one vial's contents turned blue while the other stayed green or yellow. Then refer to the experiments in which the results in both vials were the same. Ask what might have caused these experiments to turn out as they did.

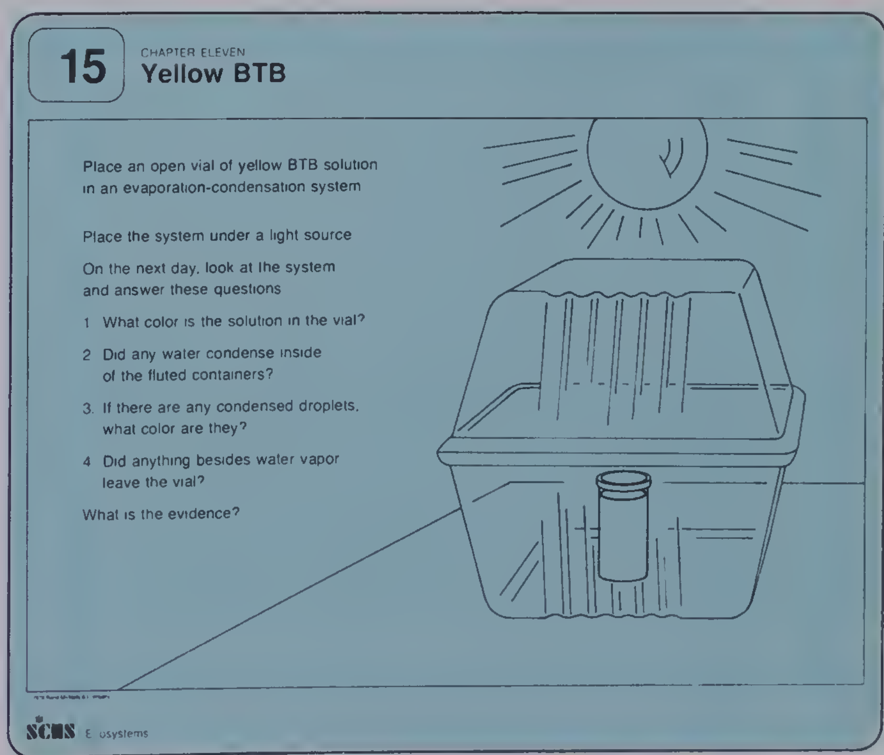
From their experiments the children may conclude that the BTB solution returned to blue because carbon dioxide left the liquid. If some vials were not capped tightly, or if an air space was left at the top of the vial, these conditions might explain why some solutions in capped vials turned blue. If some children insist that the liquid in uncapped vials became blue because oxygen got into the solution, tell them that they will be able to check this hypothesis in Chapter 12.

As a result of the discussion, some children may wish to repeat their experiments, perhaps to control some variable that they had overlooked, or to set up other experiments. If it is feasible, allow them to do so.

Cleanup. Cups and vials should be rinsed, dried, and returned to the kit.

EXTENDING YOUR EXPERIENCE CARDS

15. Yellow BTB. To see what happens when a yellow BTB solution is placed in an evaporation-condensation system the child will need a vial, yellow BTB solution, two fluted containers, masking tape, and a light source.



12 Soda Water and BTB

SYNOPSIS

The children add BTB to a bottle of soda water and note the color change and the bubbles that are given off.

After bubbling the gas produced by the soda water through a cup of BTB solution and noting the color change, children infer the nature of the gas.

After several days they note that the color of the soda water changed from yellow to green and infer what caused this color change.

Suggested time: *two days*

TEACHING MATERIALS

For each child:

student manual page 19

For the class:

1 small bottle clear soda water*
bottle opener*
masking tape*

Drawer 3

1 rubber stopper
1 plastic bag
1 twistem

Drawer 4

1 tumbler

Drawer 5

1 bottle BTB
1 plastic tube

* provided by the teacher

BACKGROUND INFORMATION

Some children still may not be convinced that the color changes they have observed in BTB solutions are caused by carbon dioxide entering or leaving. They may believe, for example, that green or yellow BTB solutions turn to blue because oxygen or air enters them. Since we have provided no test for oxygen, there is some foundation for this reasoning.

The demonstration in this chapter may convince doubtful students that only carbon dioxide causes the color change. The carbon dioxide in soda water interacts with the BTB solution that is added, and the solution becomes yellow. As this gas escapes from the soda water bottle to the tumbler, the soda water begins to change from yellow to green. Because of the large amount of carbon dioxide in the soda water, it may take a few days before an obvious change to green is observed. The blue BTB solution in the tumbler, through which the escaping gas is bubbled, will become green within an hour.

Insert one end of the plastic tube through the hole in the rubber stopper. Start at the wide end of the stopper and insert the tube only far enough so that it appears at the narrow end of the stopper.

TEACHING SUGGESTIONS

This is a discovery activity. In doing this experiment the children discover that the change from yellow to blue of the BTB solution is caused by carbon dioxide leaving the solution, rather than by oxygen entering it.

Introducing the activity. Tell the children that they will investigate the gas coming from the soda water. Since this activity is more practical as a demonstration, ask for volunteers to set up the apparatus and carry out the experiment. You might select students who are convinced that something other than carbon dioxide is changing the color of the BTB solutions. Show children the bottle of soda water and the equipment, and ask if they can suggest how this equipment could be used to test the gas that comes from the soda water.

Setting up the experiment. Have the children half-fill the tumbler with tap water, add about twelve drops of BTB, and place it in the plastic bag. The students should now open the bottle of soda water and add fifteen to twenty drops of BTB to the soda water. When the BTB is added, the soda water will turn yellow and there will be a great deal of fizzing. Ask the class if gas is entering or leaving the soda.

Push the rubber stopper into the mouth of the bottle to prevent gas escaping except through the tube. Immerse the free end of the tube in the cup of BTB solution and tape the tube to the inside of the cup so

the tube end is near the bottom of the cup. The bag should be tied around the tube so that the gas bubbling through the BTB solution will accumulate inside the bag and inflate it.

The children will notice bubbles forming inside the bottle of soda water, and soon afterward, bubbles coming out of the end of the tube immersed in the BTB solution in the cup. Ask them to describe the path that the gas is taking—from the soda to the BTB solution, not the reverse. If they have not mentioned it previously, have them identify the gas.

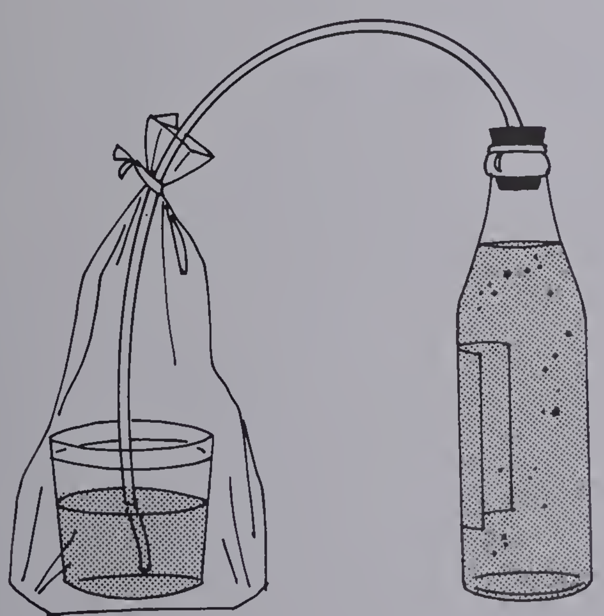
Leave the equipment assembled for a day or two, so the children can observe the color change in the soda water.

Discussion. When the class notices that the solution in the bottle has changed from yellow to green, review the sequence of events in the experiment: (1) the soda water turned yellow when BTB was added; (2) bubbles left the soda water and entered the BTB solution in the cup, turning it yellow; and (3) the soda water eventually turned green. Then ask the children to explain what caused these color changes.

Using student manual page 19. The children's responses to this problem should indicate whether they understand that only carbon dioxide causes BTB to change color. Have a discussion about Rita's and Tony's predictions. Then ask which hypothesis was correct, according to the experimental results.

Cleanup. The soda may be discarded. The rest of the equipment should be rinsed, dried, and returned to the kit.

Figure 12–1. Experimental setup to test the gas that comes from soda water.



Chapter 12 19

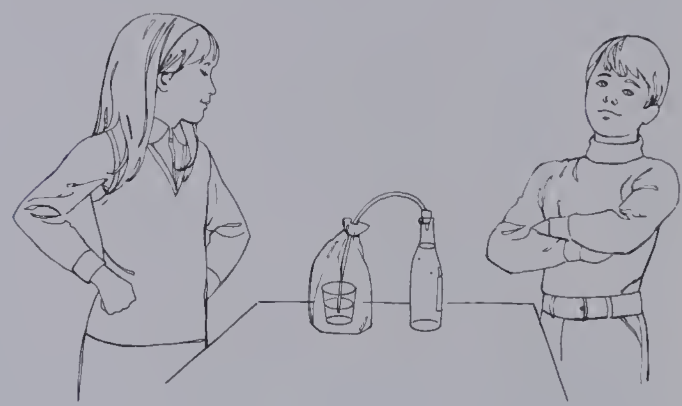
Brain Teaser

Rita and Tony added carbon dioxide to blue BTB solutions. After they looked at the solutions the next day, they disagreed about what caused the yellow solutions to turn back to blue. Tony thought that oxygen or air entered the liquid. Rita said that the carbon dioxide left the solution.

To settle their disagreement, they set up a soda water experiment and predicted the colors of both solutions at the end of the experiment.

What do you think Tony would predict? ____________________

What do you think Rita would predict? ____________________



13 Exchange of Gases in Organisms

SYNOPSIS

The children explain how they think organisms interact with the oxygen and carbon dioxide in the air.

You identify their ideas as a theory.

The children experiment to test the theory.

On the basis of the children's data you introduce a part of the oxygen–carbon dioxide cycle.

Suggested time: *one week*

TEACHING MATERIALS

For each child:

student manual pages 20–22

For the class:

Ecosystem chart (from Chapter 5)
hornwort
snails
aged tap water (several liters)*
butcher paper (optional)*

Drawer 2

light source

Drawer 3

adhesive dots (blue, green, and yellow)
straws

Drawer 4

vials with caps
tumblers

Drawer 5

3 bottles BTB

* provided by the teacher

ADVANCE PREPARATION

Before class begins, add enough BTB to each container of aged tap water to make it an obvious blue. Collect snails and sprigs of hornwort in separate cups so you can easily distribute them to the children for use in their experiments.

TEACHING SUGGESTIONS

This is an exploratory activity plus an invention lesson. The students' experiments to test ideas about gas production by plants and animals are exploratory. On the basis of the children's results, a part of the oxygen–carbon dioxide cycle is invented.

Making a theory. Display the Ecosystem chart and ask the students to explain how they think the populations on the chart interact with oxygen and carbon dioxide. List their comments on the chalkboard or on a piece of chart paper. It has been our experience that children usually offer these ideas:

- plants produce oxygen
- animals use oxygen
- animals produce carbon dioxide
- plants use carbon dioxide

We have also found that most children are unaware that plants in the dark use oxygen and produce carbon dioxide. If your class does not suggest this, do *not* mention it. The children's experiments will lead to this idea, and it is important that they make inferences from their data to produce new ideas. If someone does mention that plants in the dark use oxygen and produce carbon dioxide, list this with the other comments that are offered. Tell the class that these statements represent a theory of how plants and animals interact with oxygen and carbon dioxide.

Testing the theory. Ask the children how they can find out if the statements they have made are true. Point out the materials that are available and tell them they will be working in teams of two.

Someone should volunteer that BTB can be used as a test for carbon dioxide. Tell the students that there is no test for oxygen that they can safely use. Therefore, they will probably suggest testing whether animals produce carbon dioxide and whether plants use carbon dioxide. The two experiments can be carried out by the whole class, or some teams can do one while the remaining teams perform the other.

Do animals produce carbon dioxide? A snail may be placed in a vial containing blue BTB solution (the blue aged tap water you prepared) and the vial capped. There should be as little air as possible inside, to eliminate the possibility of gases moving out of the liquid and into the air space. A control vial with no snail may be prepared in the same way.

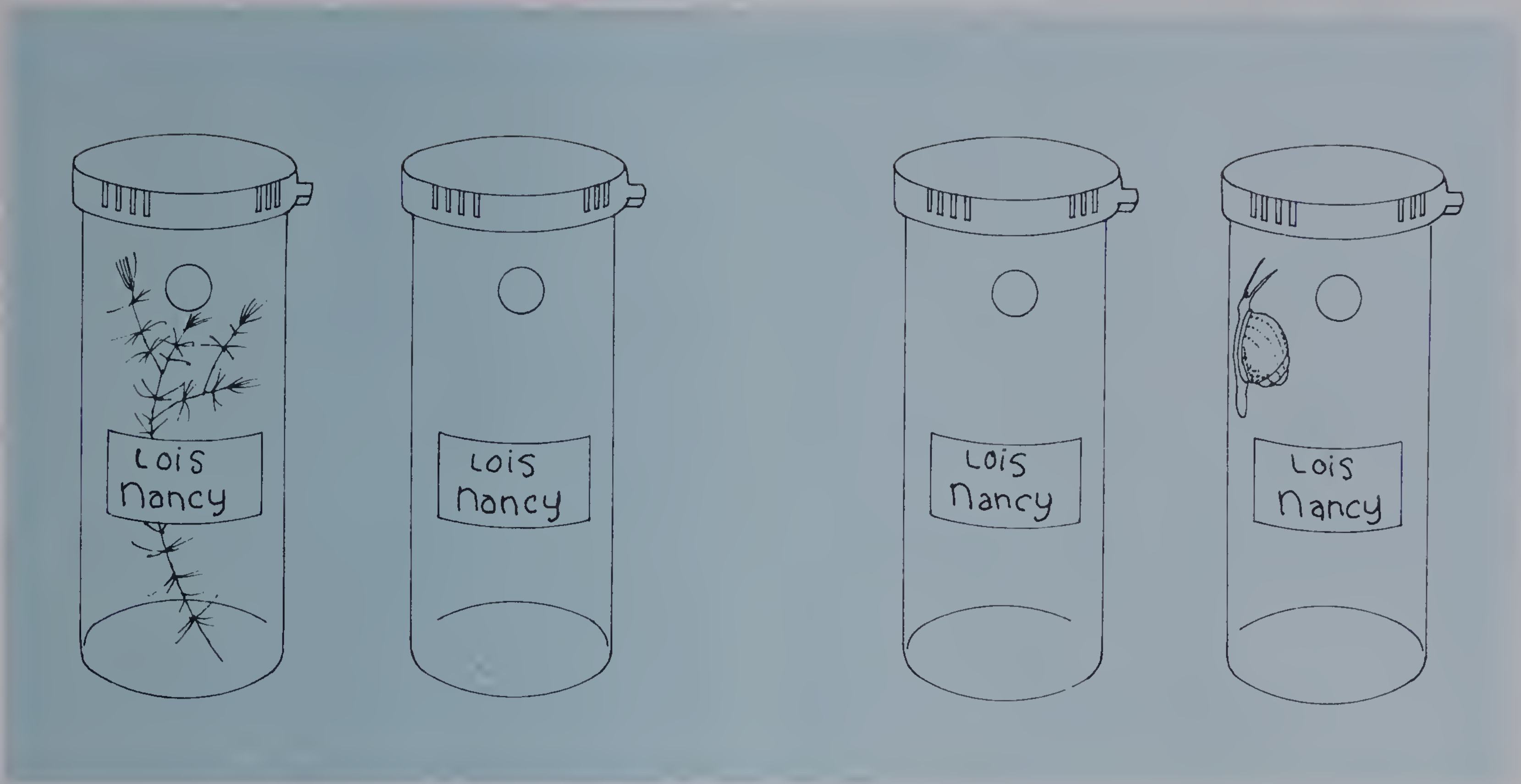


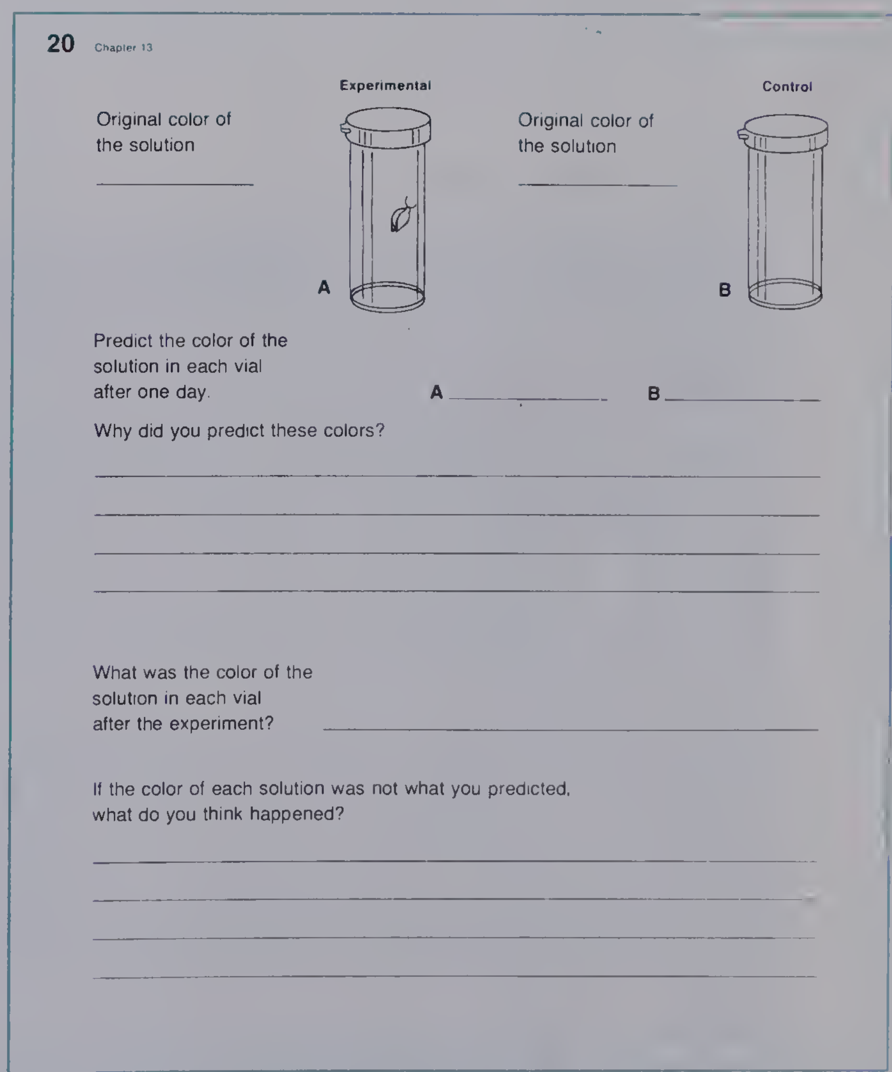
Figure 13–1. One team's experiment.

Do plants use carbon dioxide? Ask the children to blow their breaths into BTB solution to make it green. The green BTB solution may be poured into a vial, a sprig of hornwort added, and the vial capped. Again there should be little or no air space at the top. A control vial—one without hornwort, but otherwise like the experimental vial—should also be prepared.

Setting up the experiments. If each team decides to do both experiments, the members will need four vials, containing: (1) a snail in blue BTB; (2) blue BTB alone; (3) hornwort in green BTB; and (4) green BTB alone. Have the children obtain the materials they need and label each vial with their names. Each vial should also bear a colored dot as a reminder of the initial color of each BTB solution. The vials should be placed where they will not be disturbed overnight.

Using student manual pages 20 and 21. Ask the children to record their experiments and their predictions of the results they expect.

The next day have the children compare the vials containing the organisms with the control vials, and record the results of their experiments in their manuals. On the chalkboard or on a piece of chart paper, draw a table similar to the illustration, on which each team can record the results of the experiments. If you use the chalkboard, make a permanent record of the data because you will need it later. The results will probably be similar to the data illustrated, but be alert for variations that can be used for further discussion and experimentation.



20 Chapter 13

Experimental

Original color of the solution ____________

A

Control

Original color of the solution ____________

B

Predict the color of the solution in each vial after one day. A ____________ B ____________

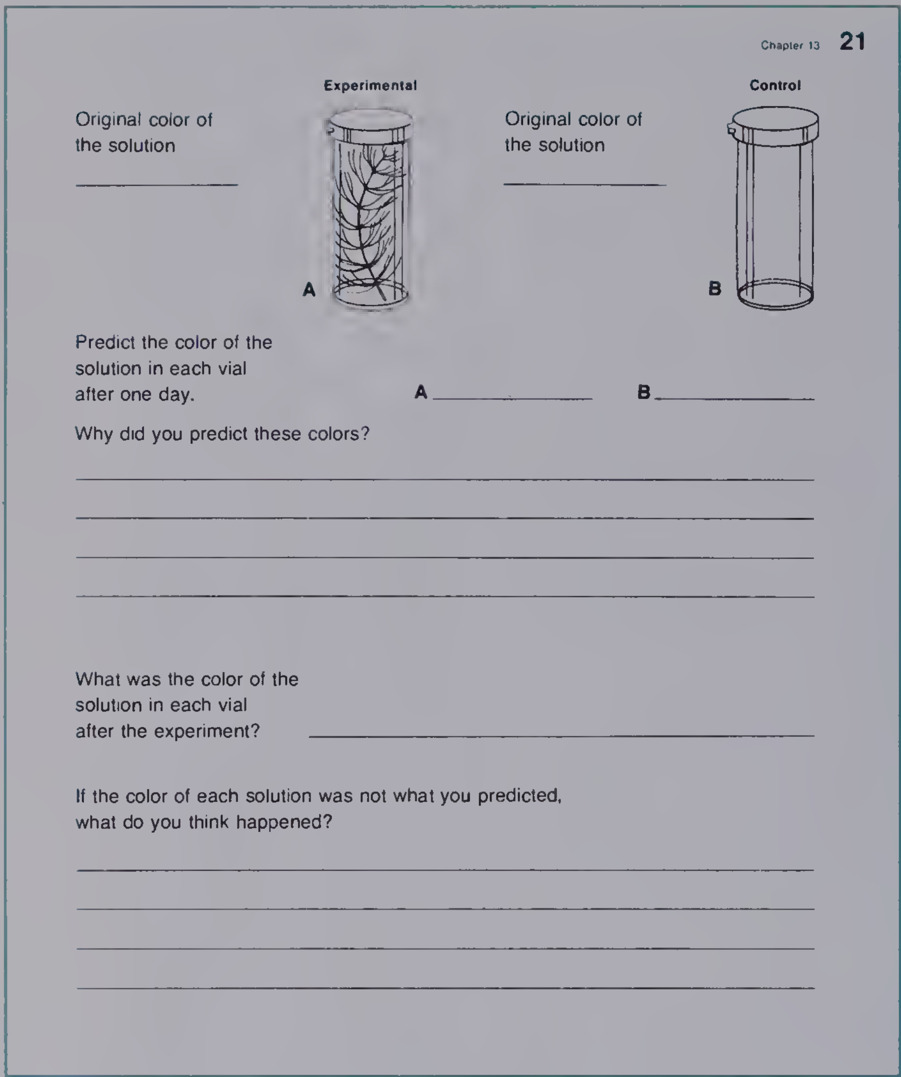
Why did you predict these colors?

____

What was the color of the solution in each vial after the experiment? ____________

If the color of each solution was not what you predicted, what do you think happened?

____


Chapter 13 **21**

Experimental **Control**

Original color of the solution ____________ A

Original color of the solution ____________ B

Predict the color of the solution in each vial after one day. A ____________ B ____________

Why did you predict these colors?

____

____

____

____

What was the color of the solution in each vial after the experiment? ____

If the color of each solution was not what you predicted, what do you think happened?

____

____

____

____

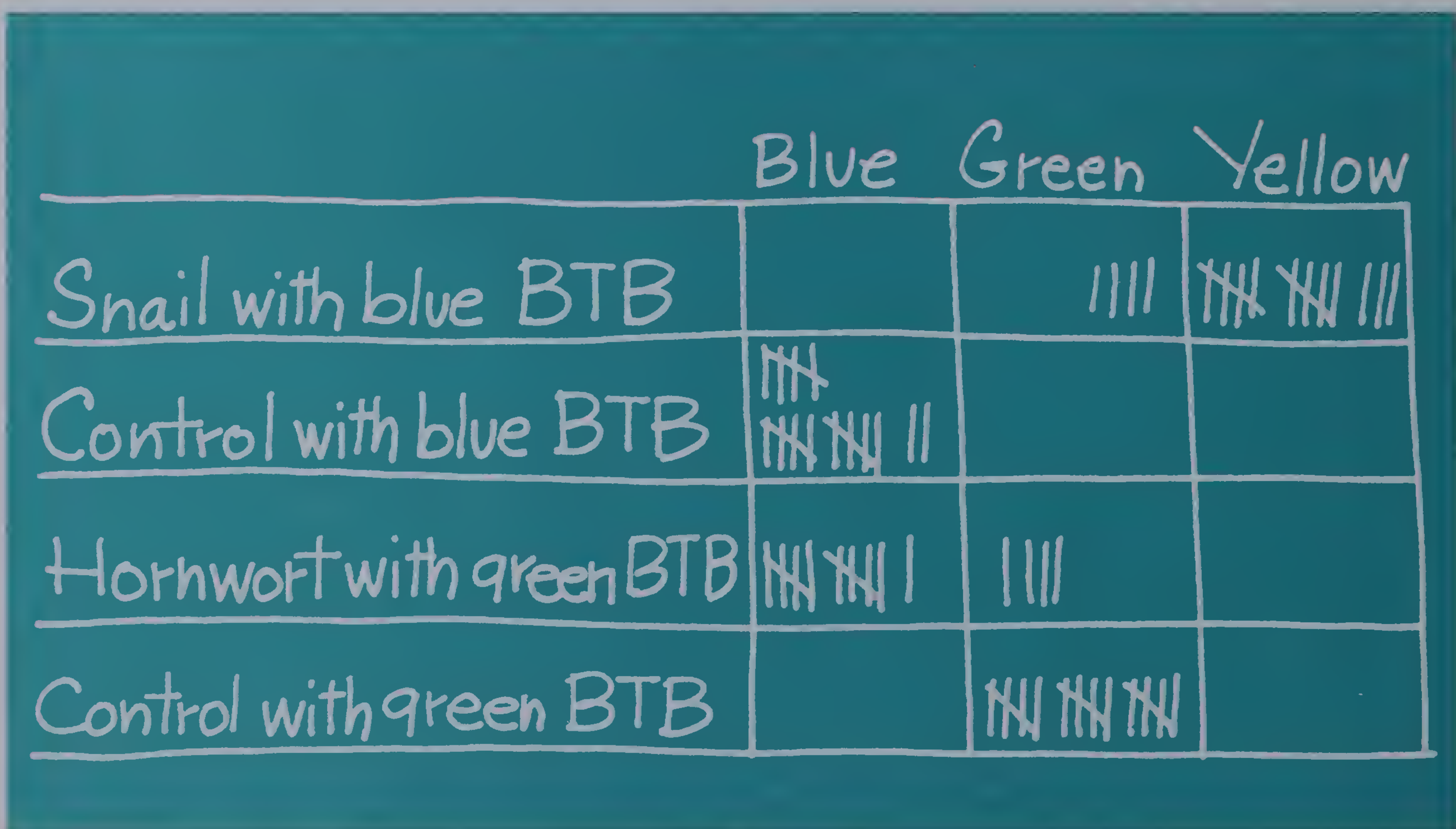
Discussing the data. After the children have recorded their results, discuss the experiments with them. Some of the questions you might ask at this time are:

- What color was the BTB solution at the start of the snail experiment?
- What color changes were observed?
- What may have caused the BTB solution with the snail to change from blue to green or to yellow?
- Do the results of the experiment support the idea that animals produce carbon dioxide?
- What color was the BTB solution at the start of the hornwort experiment?
- What color changes were observed?
- What may have caused the BTB solution to turn blue?
- Do the results of this experiment support the idea that plants use carbon dioxide?

Draw the diagram illustrated on the chalkboard or on a piece of chart paper. Tell the class that the diagram illustrates the theory concerning the oxygen–carbon dioxide relationship between plants and animals. Ask the children which part of the diagram was supported by the results of their experiments. They should recognize that the experiments supported the lower part of the diagram—that animals produce carbon dioxide and plants use it.

Some students may also claim the results support the upper part of the diagram. They may state, for

Figure 13–2. Combining the class's results.



example, that the presence of carbon dioxide in the snail vial implies that oxygen was used "because animals use oxygen and produce carbon dioxide." Point out to these children that the statement is based on the acceptance of the theory and not on evidence of the presence or absence of oxygen. Because they have no test for oxygen, they cannot obtain the evidence.

Using student manual page 22. Invite your pupils to read the brain teaser and answer the question. Even though the children do not test terrestrial animals, they should be able to infer that these organisms also produce carbon dioxide. A review of the responses should provide you with feedback about their understanding of this phenomenon.

Cleanup. Have the children take apart their experiments, returning the snails and hornwort to the aquariums. The BTB solutions should be discarded and all the vials and caps rinsed thoroughly in plain water.

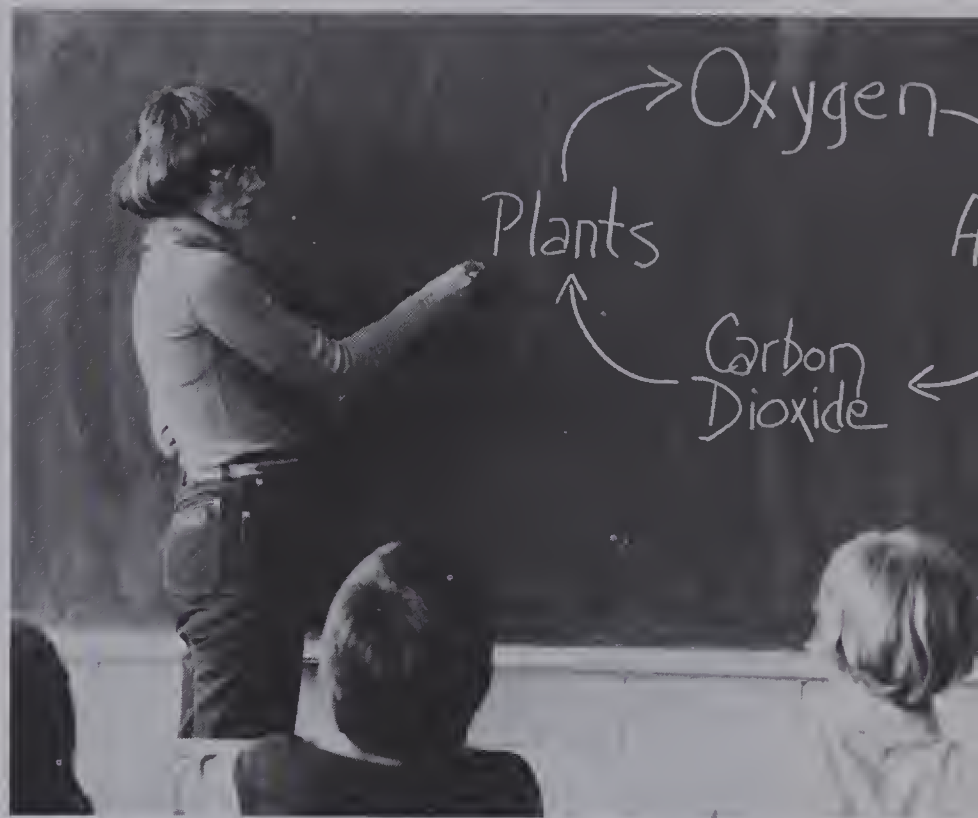


Figure 13–3. Diagraming the oxygen–carbon dioxide relationship between plants and animals.

22 Chapter 13

Brain Teaser

Tom and Debbie tried an experiment. They put 3 crickets in a jar and added a vial filled with blue BTB solution. Then they capped the jar. The next day they looked at the experiment.

Do you think the BTB stayed blue or that it changed color? Explain.

____

____

____

____

____

14 "Inventing" the Oxygen–Carbon Dioxide Cycle

SYNOPSIS

The students repeat the hornwort and snail experiments, this time placing the vials in both light and dark.

On the basis of the data, the complete oxygen–carbon dioxide cycle is introduced.

Suggested time: *two sessions*

TEACHING MATERIALS

For each child:

student manual pages 23–25

For the class:

hornwort
snails
aged tap water*
butcher paper*

Drawer 2

light source

Drawer 3

adhesive dots (blue, green, and yellow)
straws

Drawer 4

vials with caps
tumblers

Drawer 5

3 bottles BTB

* provided by the teacher

BACKGROUND INFORMATION

Children accept the fact that animals produce carbon dioxide which plants use. However, they often reject experimental data suggesting that plants also produce carbon dioxide. Most children and many adults have difficulty in accepting data contrary to their beliefs, but willingness to accept data when these conflict with one's beliefs is basic to the scientific process. In this chapter, the students are confronted with a contradiction that they can resolve only by more experimentation and by collecting more data.

TEACHING SUGGESTIONS

Further exploration of gas production in plants and animals leads to the invention of the complete oxygen–carbon dioxide cycle.

Repeating the experiments. Ask your students if the results of their experiments with snails, hornwort, and BTB solution would have been different if they had placed their vials in the dark. Encourage their speculation but do not expect them to volunteer that plants in the dark use oxygen and give off carbon dioxide.

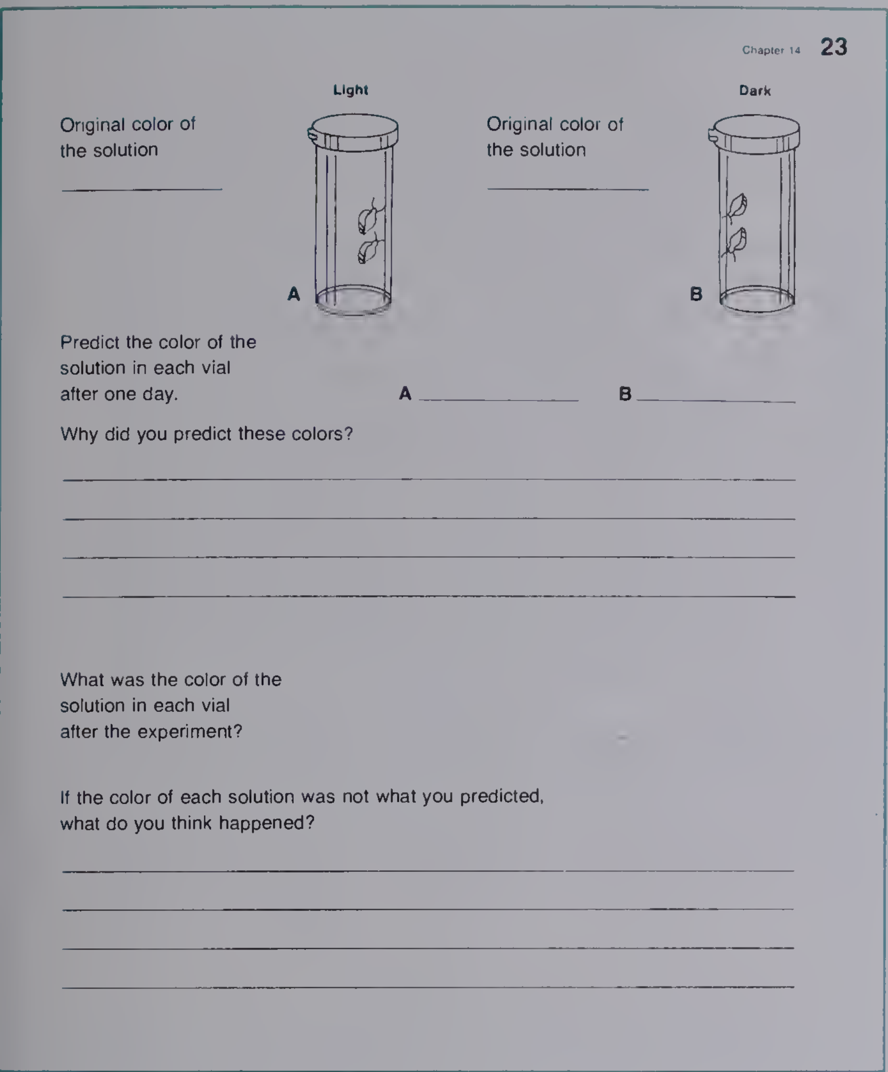
Ask them to set up their experiments again, but this time to place half the snail and hornwort vials in a dark closet or box. If some of the children do not wish to repeat the snail and hornwort experiments in the light, let them place their vials in the dark only. As students set up their experiments, remind them to label the vials with their names, colored dots, and *light* or *dark*.

Using student manual pages 23 and 24. After the students have placed their vials in light and dark, ask them to record their predictions in their student manuals. On the next day, after they have observed their experiments, have them record their results on page 23 of the student manuals.

Draw a chart similar to the one in Figure 14-1, on which the children can construct a class record of their data. If your students did not repeat the experiments in the light, you should transfer those data from the previous chart.

After the children have finished recording, discuss the experimental results with them. You might ask some of these questions during the discussion:

- What color was the BTB solution at the start of the snail experiment?
- What color changes were observed?
- Did the dark seem to make a difference in the results?
- What may have caused the BTB solution containing the snail to change from blue to green or yellow?


Chapter 14 23

Light

Dark

Original color of the solution ____________

Original color of the solution ____________

A

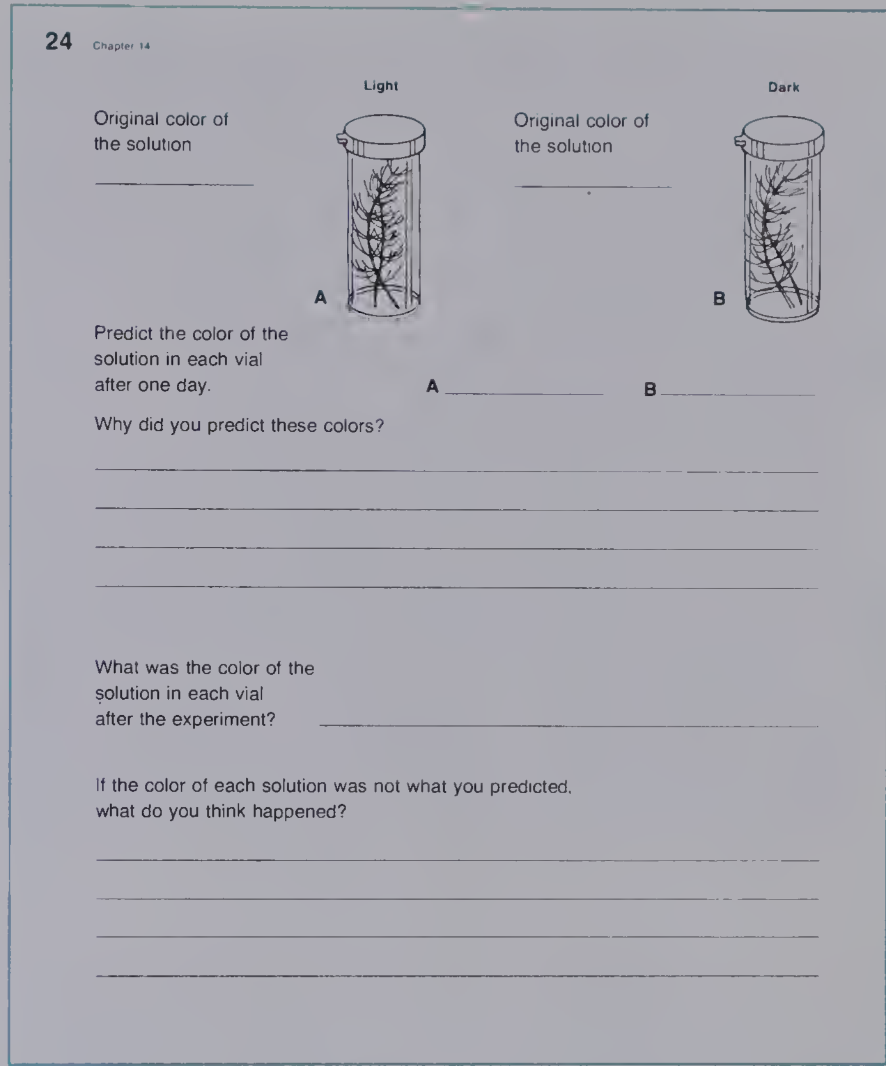
B

Predict the color of the solution in each vial after one day. A ____________ B ____________

Why did you predict these colors?

What was the color of the solution in each vial after the experiment?

If the color of each solution was not what you predicted, what do you think happened?


24 Chapter 14

Light

Dark

Original color of the solution ____________

Original color of the solution ____________

A

B

Predict the color of the solution in each vial after one day. A ____________ B ____________

Why did you predict these colors?

What was the color of the solution in each vial after the experiment? ____________

If the color of each solution was not what you predicted, what do you think happened?

- What color was the BTB solution at the beginning of the hornwort experiment?
- What color changes were observed?
- Did the dark seem to make a difference in the results?
- What may have caused the BTB solution in the dark to remain green?

Verifying the results. The children should reason either that hornwort does not use carbon dioxide in the dark or that it produces carbon dioxide in the dark. Discuss the possible explanations. It has been our experience that children are unwilling to accept these ideas. Believing that plants do not produce carbon dioxide, they seek explanations that will support their belief. Some of the explanations might be "the cap leaked," "the hornwort died," or "the water had something to do with it."

Encourage your students to repeat their experiments or to devise new ones that will help them decide which experiment is correct. They should rinse their vials before making new solutions. Ask the students what color BTB solution they would have to use in order to test their hypotheses. If they use a blue solution, and the hornwort produces carbon dioxide in the dark, the blue BTB should change to green or yellow.

Figure 14–1. Getting ready to make a class record.

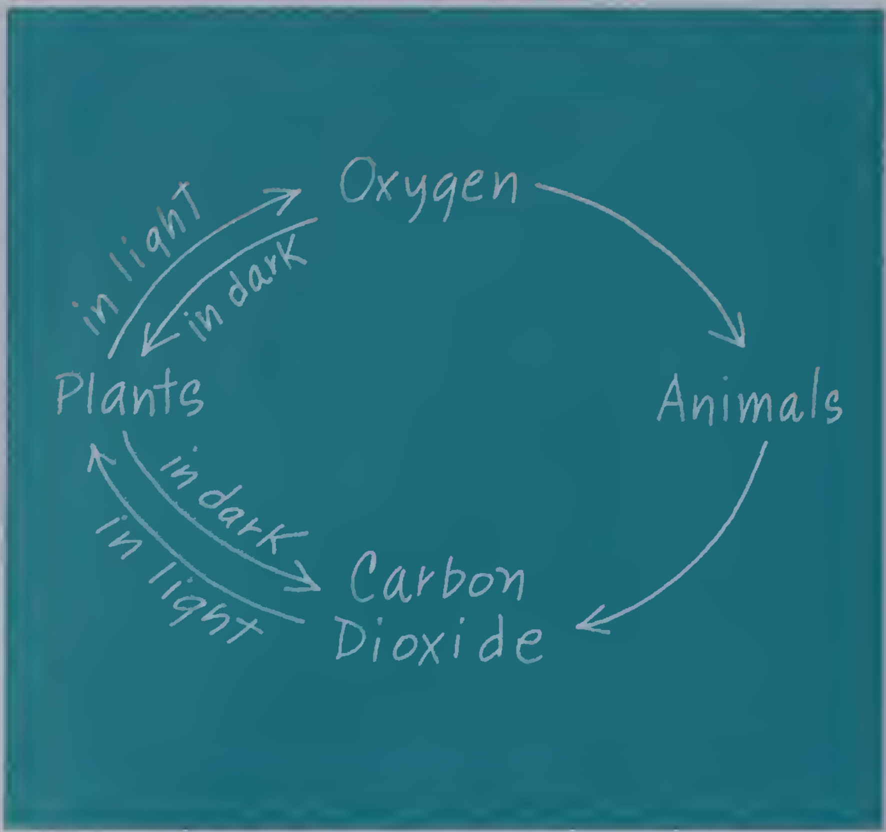


Figure 14–2. The oxygen–carbon dioxide cycle.

On the following day, have the children examine their experiments and check the results. Fill in the chart you prepared earlier. After recording and reviewing their data, the children should recognize that plants produce carbon dioxide in the dark, completing the oxygen–carbon dioxide cycle.

All the data charts that have been constructed should be displayed. Make a sketch similar to Figure 14-2 and tell the class that this represents all the collected data.

The children may recognize that this diagram represents a circle or cycle. Tell them that this is the oxygen–carbon dioxide cycle, representing how organisms and these two gases interact. Both oxygen and carbon dioxide are cycled through organisms and the environment.

Using student manual page 25. The brain teaser requires your students to apply their understanding of the experimental data. Because the situation is probably unfamiliar to the children, a certain amount of guesswork may be necessary. You may use this brain teaser to obtain feedback about individual children's understanding of gas relationships, as a problem for small groups to work on, or as a stimulus for class discussion.

Cleanup. The hornwort sprigs and snails should be rinsed and returned to the classroom aquariums and the liquid in the vials disposed of. All the vials and caps should be thoroughly rinsed and returned to the kit. Rinse and fill the containers with tap water so you will have aged water on hand.

OPTIONAL ACTIVITY

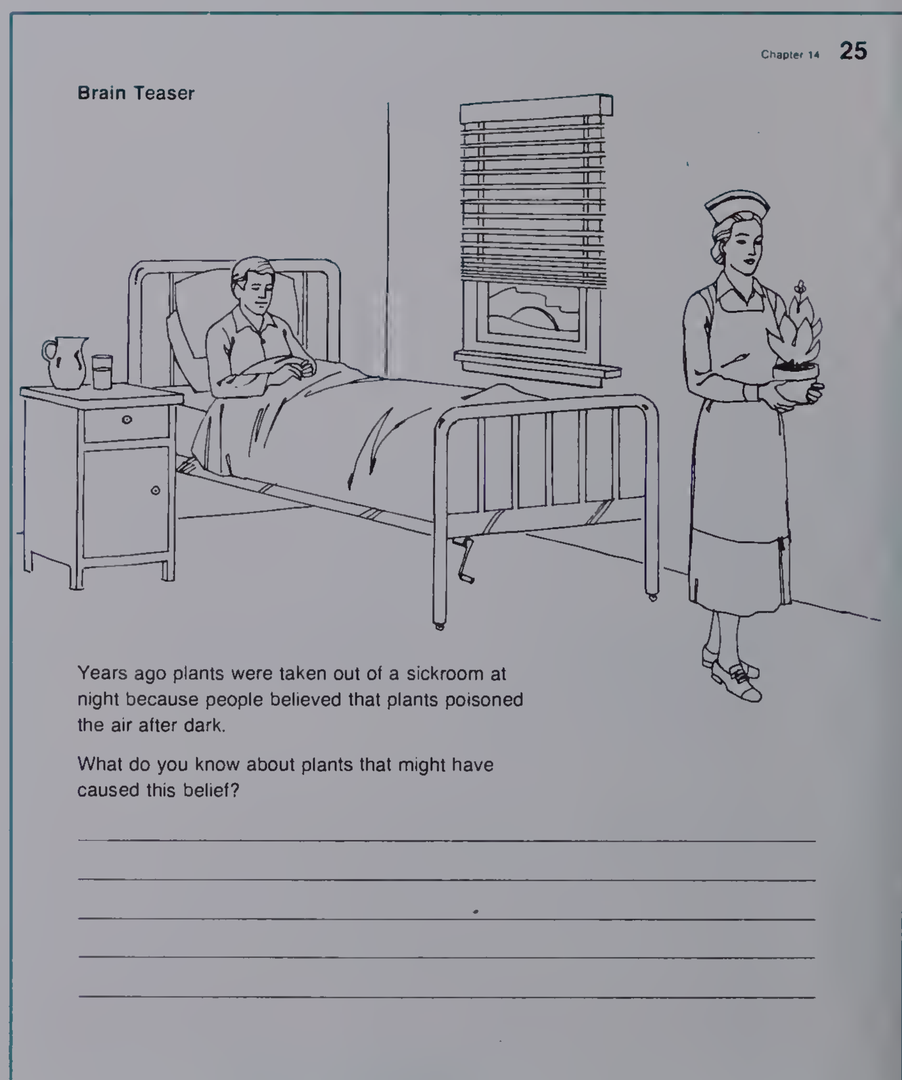
Hornwort and snails together. Ask the class what they think might happen in the following experiment, and then have them set it up: a snail and a sprig of hornwort are placed in a vial filled with green BTB solution, capped and placed under the light source. A control vial with green BTB only should also be set up. Diagram the setup you have described so that it will be easier for the children to visualize what you have in mind. Have them predict the color that the BTB solution will be on the next day and the possible effect of the confinement on the snail and hornwort.

Then suggest that a similar vial be set up, but placed in the dark. If some of the children say that under these conditions both the snail and hornwort will produce carbon dioxide and therefore die, do not insist that this comparison experiment be done.

EXTENDING YOUR EXPERIENCE CARDS

16. Water and Carbon Dioxide. Children discover that hornwort left overnight adds carbon dioxide to the water. They will need two vials with caps, one green dot, blue BTB, a dark cupboard, and hornwort.

17. Temperature and Carbon Dioxide. Two vials, blue BTB solutions, a refrigerator, aluminum foil, a light


Chapter 14 25

Brain Teaser

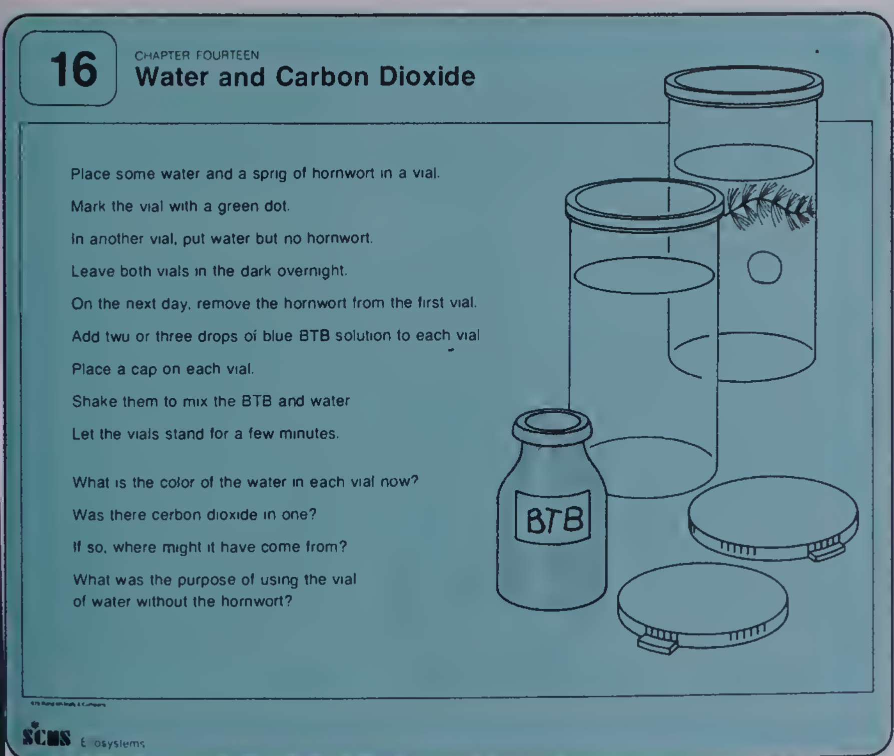
Years ago plants were taken out of a sickroom at night because people believed that plants poisoned the air after dark.

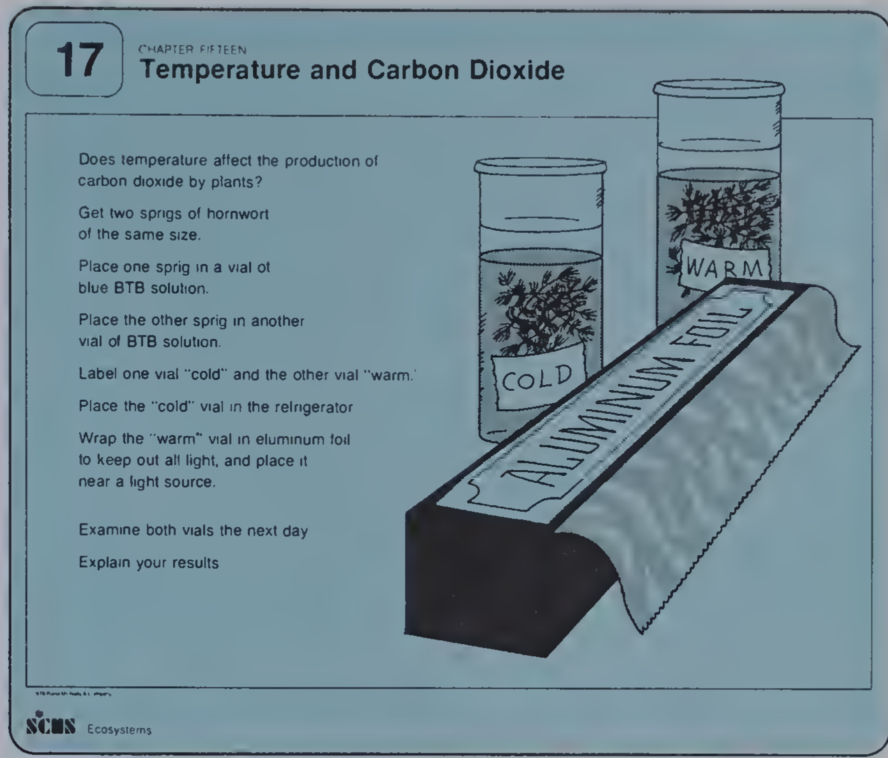
What do you know about plants that might have caused this belief?

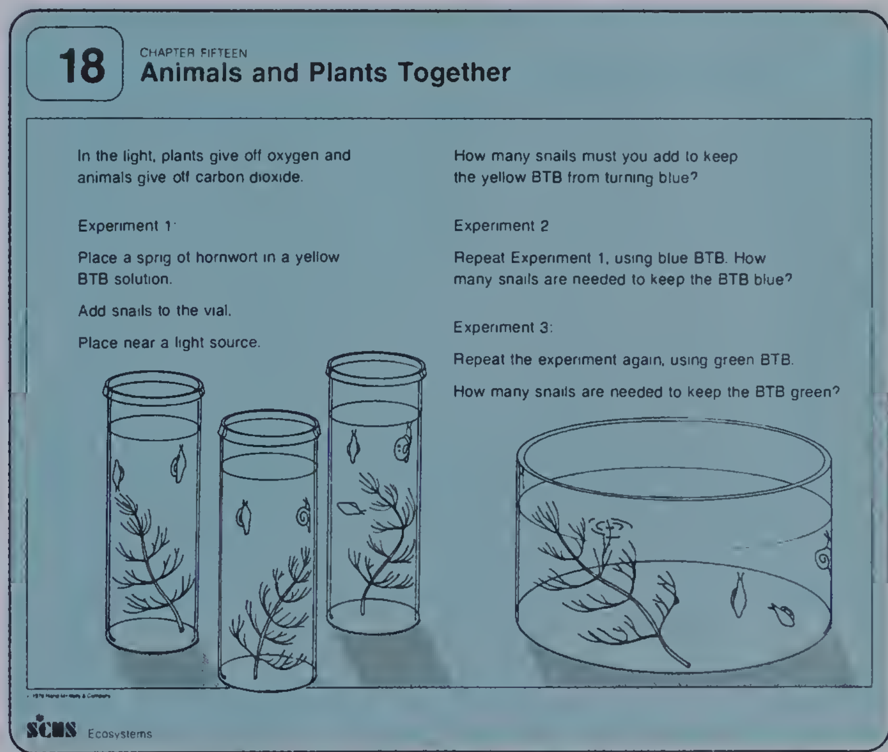
Figure 14–3. Diagraming an experimental setup for the optional activity.

source, and hornwort are used in testing the effect of temperature on carbon dioxide production.

18. Animals and Plants Together. Students experiment with hornwort, snails, and BTB to find out if they can balance the production of carbon dioxide by snails with its use by hornwort. The children will need snails, hornwort, yellow BTB solution, green BTB solution, blue BTB solution, a light source, and three vials.







15 Land Plants and Gases

SYNOPSIS

The children enclose pea plants and vials of BTB in plastic bags.

They place some of the setups in the dark, and others in the light.

The next day they observe the vials of BTB and determine which plants produced carbon dioxide.

Suggested time: *two sessions*

TEACHING MATERIALS

For each team of four children:

1 planter containing pea plants (prepared in Chapter 6)
masking tape*

Drawer 3

1 plastic bag
1 twistem

Drawer 4

1 vial

For the class:

Drawer 2

light source

Drawer 5

3 bottles BTB

* provided by the teacher

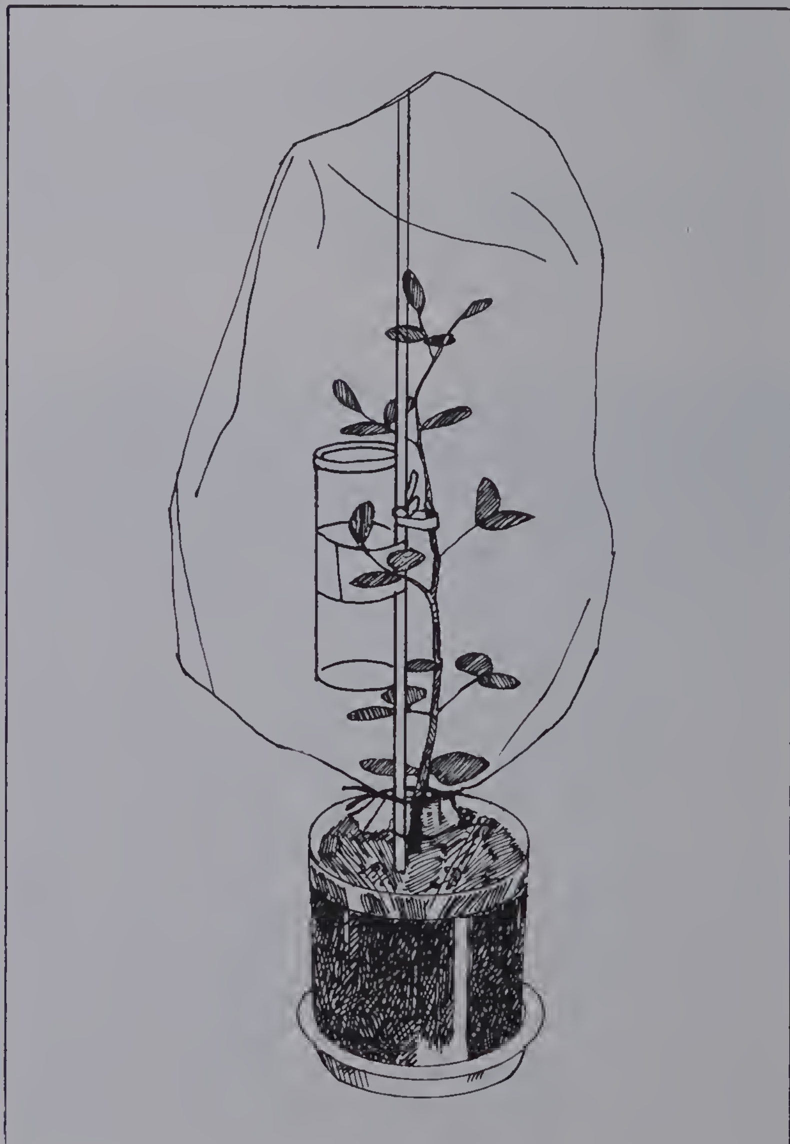
TEACHING SUGGESTIONS

This is a discovery activity in which the children test whether land plants produce carbon dioxide just as aquatic plants do.

Introducing the activity. You might wish to begin this activity by asking the children whether the gas relationships observed in their earlier experiments with hornwort are the same in land plants. There may be some doubt because hornwort was surrounded by water, and land plants are surrounded by air.

Setting up the experiment. Tell your pupils that they will be doing experiments with pea plants in light and dark. Fill a vial about one-quarter full of water and add one or two drops of BTB. Demonstrate how to assemble the equipment as follows: (1) Fasten the vial to a planter stick with masking tape. The top of the vial should be approximately at the middle of the stick. (2) Push the planter stick into the soil of a planter cup near the pea plant. (3) Enclose the stick, vial, and pea plant (but not the planter cup) in a plastic bag and secure the whole system with a twistem at the base of the stem. Warn the children not to crush the plant stem.

Figure 15–1. Testing a plant for gas production.



Have the children decide which teams will place their plants in light and which in the dark. Then they may obtain their plants and other equipment and set up the experiments. They should label the vials with their names and *Light* or *Dark* before enclosing them in the plastic bags.

Observing the results. On the next day ask the students to open their systems, remove the vials, and line them up so the results can be seen by everyone. Draw a chart on the chalkboard similar to the one shown. Have one member of each team record the results of his team's experiment by placing a mark in the appropriate section of the chart.

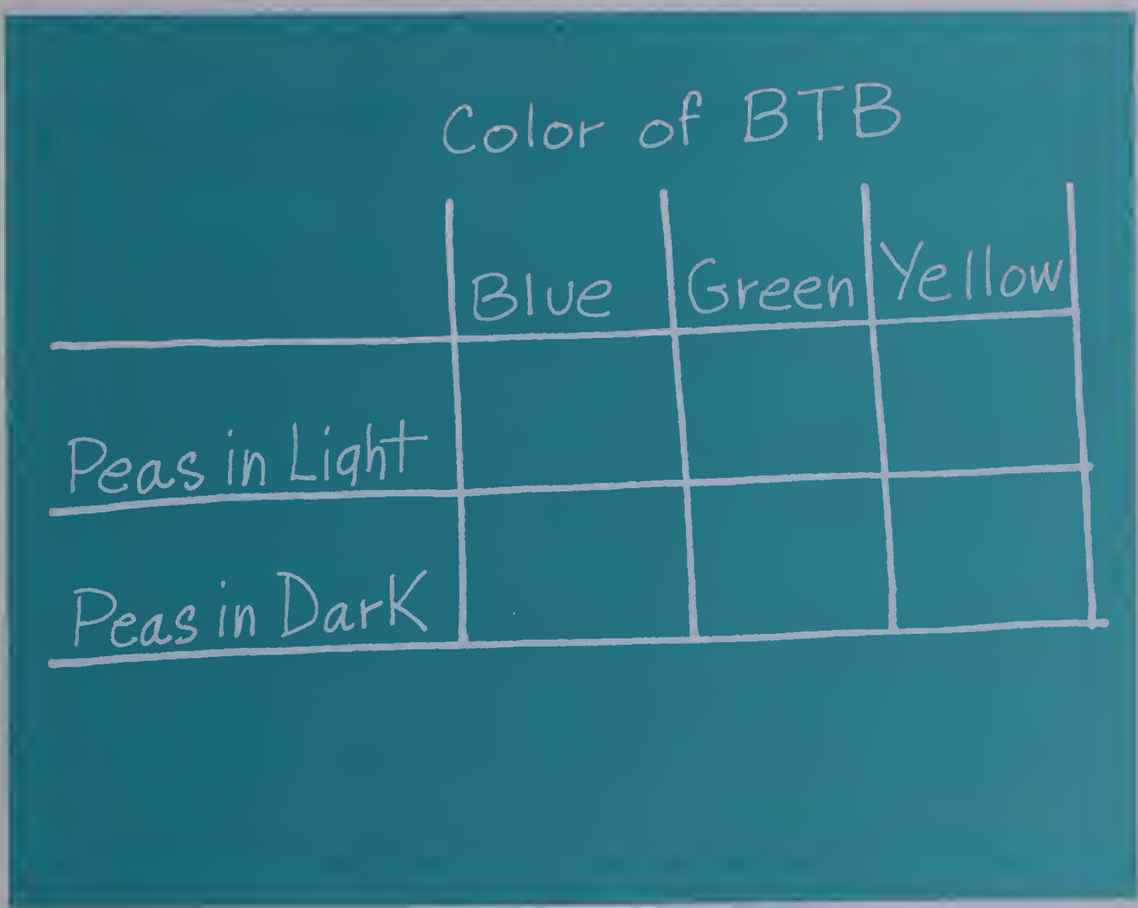
Once the data are recorded, ask the children to describe any differences between setups kept in the dark and in the light. Then ask them to explain the differences in the results. They should be able to infer from their results that land plants produce carbon dioxide in the dark.

Cleanup. The vials, planter cups, sticks, and planter bases should be rinsed, dried, and returned to the kit. The soil, plastic bags, and twistems may be discarded.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concept of gases produced by organisms, turn to page 98 of the evaluation section at the back of the guide.

Figure 15–2. A chart for all teams' results.



Part Four

RAND McNALLY SCIIS

Cycles in an Ecosystem

OBJECTIVES

To consider ecosystems in terms of materials cycling through organisms and the environment.

To identify major United States ecosystems, determine the class's local ecosystem, and relate ecosystems to geography.

To point out changes in natural ecosystems that have resulted from human activities.

BACKGROUND INFORMATION

The cycling of materials through organisms and their environment is an important part of the ecosystem concept. Both plants and animals take materials out of the environment and eventually release them again.

Organisms and the environment are both affected by the cycling of materials. Processes of life in plants and animals depend on a constant intake of materials from the environment. The effect on the environment of the cycling of materials is not as dramatic as it is on organisms. The environment would still exist even if animals or plants were not involved with the cycling of materials. However, the nature of the environment would change. If animals ceased to breathe carbon dioxide into the air, the amount of carbon dioxide present would eventually be reduced; if decomposers did not replace minerals in the soil, the soil eventually

Figure IV–1. When a rock weathers enough, the substances in it can re-enter the food-mineral cycle.

could not support plant growth; if there were no plant roots, water would not be readily held by the soil and erosion would result. Cycling of materials is essential to maintaining the environment's ability to support life.

Food-mineral cycle. Oxygen, carbon dioxide, and water are some of the materials cycled in an ecosystem. Minerals also move in cycles. Minerals in the soil are used by plants and become part of the plants' stored food and bodies. When a plant dies, molds and bacteria use the dead plant as a food source, decomposing it; and the plant's minerals are returned to the soil. If the plant is eaten by an animal, the minerals pass on to the animal and become a part of its body. The minerals pass all the way along a food chain, returning to the earth as part of animal wastes or when an animal in the chain dies and is decomposed. Once back in the soil, the minerals can be used by plants and the cycle starts all over again.

OVERVIEW

In Chapter 16, "Cycling of Materials in an Ecosystem," you introduce the food-mineral cycle. The children apply their knowledge of this cycle, the water cycle, and the oxygen–carbon dioxide cycle as you build a diagram to illustrate the interaction between the biotic community and its environment. In Chapter 17, "Natural Ecosystems," the various types of ecosystems found in North America are identified. The children attempt to identify the type of ecosystem they live in. They also discover the distribution of the various ecosystems on a map of the United States and relate the types of ecosystems to the mountains and wind patterns that affect the water cycle.

Chapter 18, "Artificial Ecosystems," deals with human modifications of natural ecosystems and sets the stage for the introduction of pollution in Part Five.

16 Cycling of Materials in an Ecosystem

SYNOPSIS

After reviewing the food relations in a community and the release of minerals by decomposers, you introduce the food-mineral cycle.

Using information supplied by the children, you construct a diagram that illustrates the cycling of minerals, water, oxygen, and carbon dioxide.

Suggested time: ***one class session***

TEACHING MATERIALS

For the class:

Ecosystem chart (from Chapter 5)
felt pen or crayon*

Drawer 1

blank Ecosystem chart
Cycles in an Ecosystem label

* provided by the teacher

TEACHING SUGGESTIONS

This is an invention activity based on information the children have previously learned.

Food-mineral cycle. Post the Ecosystem chart from Chapter 3 and the blank chart together where all the children can see them. Review with the students the names of the populations that are written in the various sections of the completed chart.

- Remind the children that plants are producers because they produce all the food that supports the community; that the animals are consumers because they eat the food produced by plants; and that molds and bacteria are decomposers, because they break down and eat the bodies of plants and animals.
- Write *Producers, Consumers,* and *Decomposers* in the appropriate sections of the new chart. If you wish, write *Plants* and *Animals* in parentheses under the appropriate titles.
- Connect the sections with arrows showing the direction of food transfer as illustrated in Figure 16-2. Ask the children what the arrows represent.
- If no one remembers, tell the students that they represent food used by the consumers and decomposers.
- Then write *Food* across or along each arrow.
- Ask the children what happens to plants and animals when they die.
- They should recall that these, along with animal wastes, are food for decomposers.
- Then ask what happens to this material after it is decomposed.
- Someone may also remember that the products of decomposition are called *minerals*. Write the word *Minerals* beneath the Producers section.
- Draw an arrow from Decomposers to Minerals and another arrow from Minerals to Producers.
- Remind your students that minerals are part of the raw materials used by plants.
- Trace the circle made by the arrows and tell the children that this circle represents the *food-mineral* cycle.
- Tell the children that animals also need minerals, and ask them where they obtain these. Ask,

  "How do the minerals contained in the bodies of plants and animals get back into the soil?"
  "What would happen to the plants if there were no decomposers?"

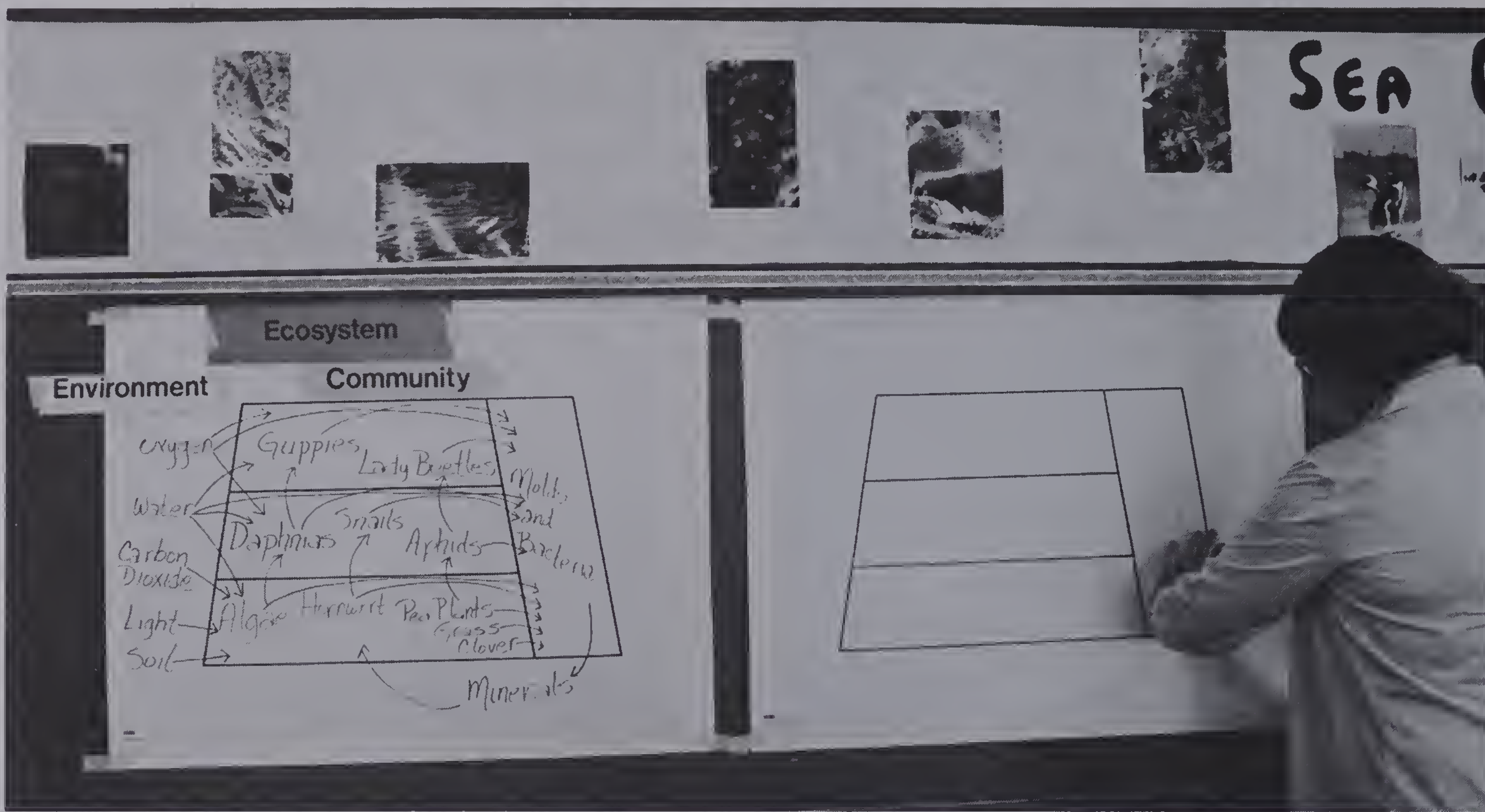
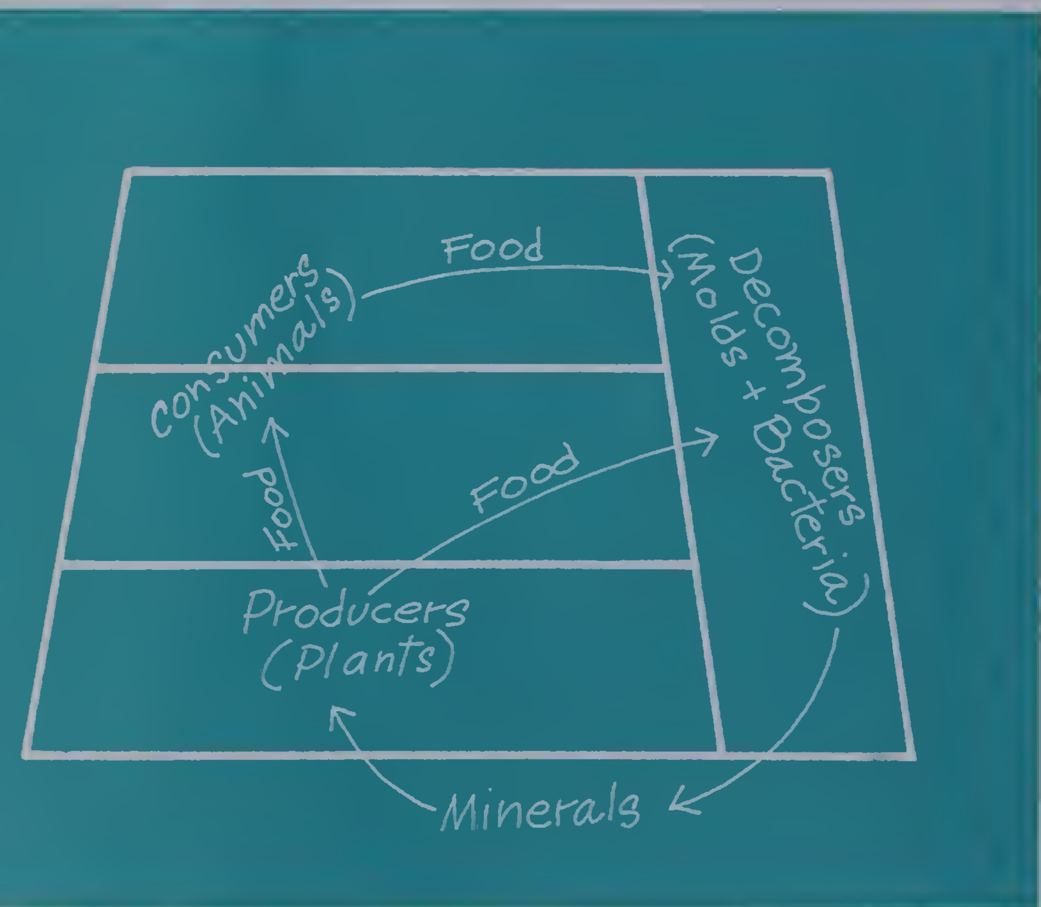


Figure 16–1. Starting the second Ecosystem chart.

Figure 16–2. Diagram of the food-mineral cycle.



Water cycle. Draw a cloud on the new chart above the diagram and connect the cloud to the diagram with arrows, as illustrated in Figure 16-3.

- Explain that the arrow pointing away from the cloud represents rain falling to the earth, and the other arrow represents water evaporating from the earth.
- Tell your students that this diagram now includes the water cycle.
- Using your hand to block out the arrow to the cloud, ask the children what would happen to plants and animals that live on land if all evaporation of water ceased. (Without evaporation there would be no life except in large bodies of water.)
- In like manner, block out the arrow representing rainfall and ask what would happen to land animals if there was no rain.

Oxygen–carbon dioxide cycle. To review the oxygen–carbon dioxide cycle write *Oxygen* and *Carbon dioxide* on the diagram, as in Figure 16-4.

- Ask the children if consumers produce carbon dioxide.
- Draw an arrow from the sections containing consumers to Carbon dioxide.
- Now ask what organisms use carbon dioxide, and draw an arrow from Carbon dioxide to Producers.
- Then ask, "What organisms use oxygen?" "What organisms produce it?"

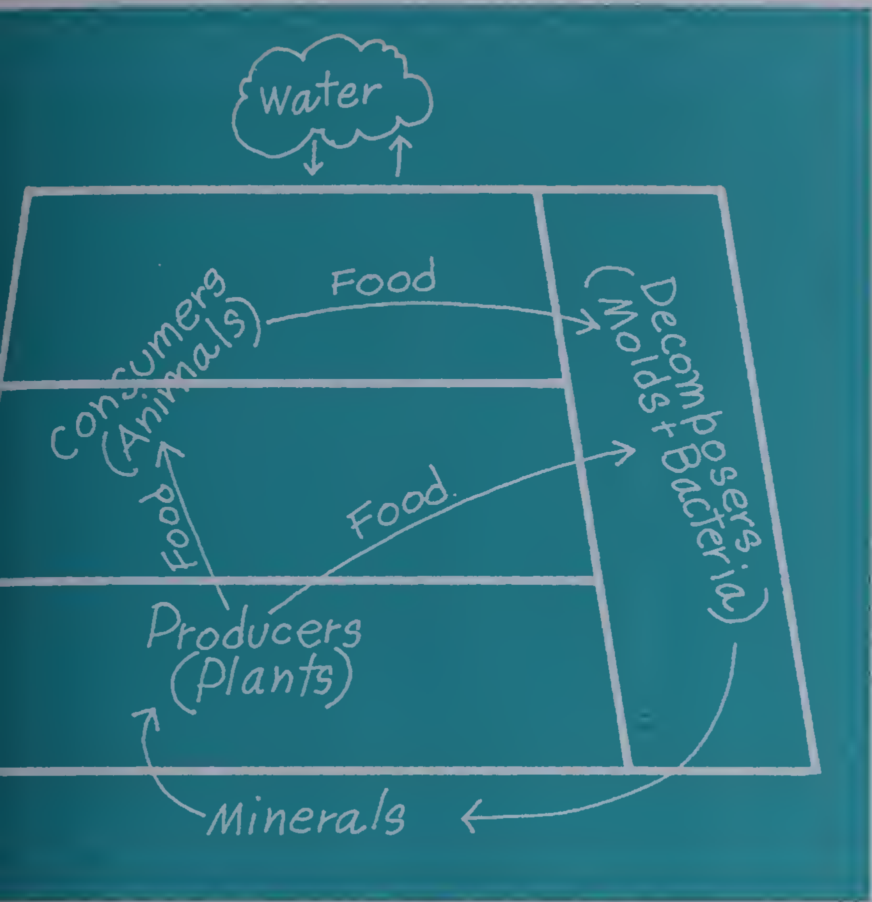


Figure 16-3. The water cycle added to the diagram.

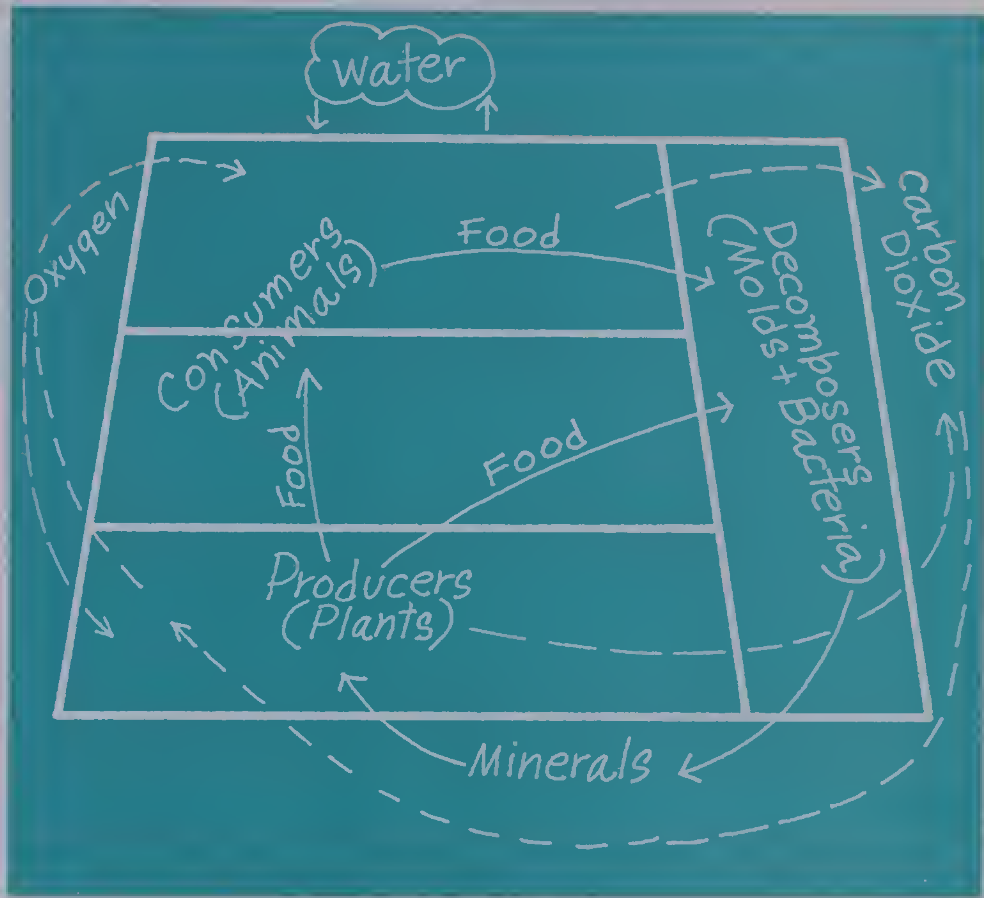


Figure 16-4. The oxygen-carbon dioxide cycle added to the diagram.

- Draw the appropriate arrows to and away from Oxygen.
- Block out one arrow at a time and ask what would happen if that cycle were interrupted.

Feedback and discussion. Indicate the three cycles illustrated on the diagram. Tell the children that the cycles represent some of the interaction between the community and the environment. Then attach the Cycles in an Ecosystem label. (Save the chart for use in later chapters.)

Ask the children to identify evidence of these cycles in the ecosystem in which they live. They may mention air, clouds, or rain. Someone may mention decay of leaves or of dead animals.

17 Natural Ecosystems

SYNOPSIS

The children identify pictures of the various natural ecosystems and their locations in North America.

They identify the ecosystem in which they live and attempt to explain why ecosystems differ.

Suggested time: *one session*

TEACHING MATERIALS

For each child:

student manual pages 26–28

For the class:

masking tape*

Drawer 1

4 sets of Ecosystems photographs†
4 sets of Ecosystems data cards
North American Ecosystems Maps 1, 2, and 3

* provided by the teacher
† For identification by the teacher, the photographs are numbered (1) tundra, (2) taiga, (3) deciduous forest, (4) tropical rain forest, (5) scrub forest, (6) grassland, and (7) desert.

BACKGROUND INFORMATION

Communities of plants and animals cover the earth, but because the environmental conditions vary from area to area, the kinds of plants and animals that make up the communities differ.

On the continent of North America, there are seven distinctly different areas that—when the communities are considered together with the physical environment—represent seven different ecosystems.

The seven ecosystems contain characteristic species of both animals and plants. Because the plants are generally more distinctive, however, only the plants will be used to differentiate the ecosystems.

Plants differ in their adaptations to environmental factors such as soil type, temperature, amount of sunlight, and rainfall. These factors vary across the North American continent and determine the nature of plants that flourish in the different areas.

Tundra. In the far North, the arctic climate is cold with long, dark winters. Frost may occur at any time of the year, and a few feet below the surface the soil remains permanently frozen. Dwarf trees are common, but no tall upstanding trees are to be found. Mosses and lichens cover large areas.

Taiga. Farther south in Canada and in parts of the northern United States, temperatures in winter can be as severe as those in the tundra, but there is a well-defined summer growing season of three to six months. This suffices for heavy growth of hardy trees, and the taiga as a whole is a tremendous forest of coniferous (evergreen) trees.

Deciduous forest. The eastern part of the United States is temperate, with cold winters and warm summers. The annual rainfall is about 100 cm (40 in). This climate supports forests of hardwood trees that have leaves in the summer but none in the winter.

Rain forest. This type of ecosystem flourishes where there is a great deal of rain and a long growing season. Rain forests are characterized by lush plant growth, including hundreds of species of trees. The southern tip of Florida and much of Hawaii are tropical rain forests.

From southern Alaska to Oregon is found a middle-latitude rain forest, where trees of the taiga grow to rain-forest heights. This zone is complex and confusing, and it is not pictured on the North American Ecosystems map or represented on the data cards.

Scrub forest. This ecosystem consists of open forests of low trees. It extends along the coast of California. There is a rainy season in the winter, but the summers are dry. The temperature is mild throughout the year.

Grasslands. East of the Rocky Mountains are flat areas covered with grass—grasslands or prairies. Annual rainfall may range between 25 and 75 cm (10 and 30 in) per year, which will support the growth of grass, but not trees. The winters are cold and the summers are hot.

Desert. Any area with an annual rainfall of less than 25 cm (10 in) is a desert. The characteristic plants are cactuslike and have spines rather than leaves. Deserts have an abundance of sunshine and can be very hot during the summers. Deserts can be found in the western and southwestern United States.

Sunlight and precipitation. The temperature and amount of sunlight decreases from south to north in the United States, while the amount of rain is determined by prevailing wind currents and mountain ranges. Generally, winds blow from west to east across North America. Moisture picked up by evaporation from the Pacific Ocean forms clouds that are blown eastward. When these winds strike the mountain ranges in Washington, Oregon, and California, much of the moisture falls as rain or snow on the mountains. As a result, areas east of those mountain ranges receive little rain and are deserts. The Rocky Mountains again receive rain or snow, but the plains immediately to the east are semideserts of high, dry grasslands. From there on to the Atlantic coast, the general tendency—with many local irregularities—is for an increase in rainfall, largely because of moist air that periodically moves northeastward from the Gulf of Mexico.

TEACHING SUGGESTIONS

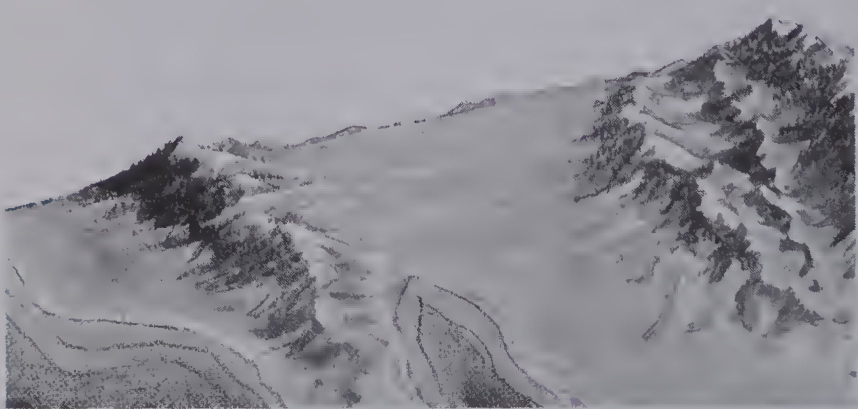
This activity involves exploration and invention lessons. In the exploratory part, children observe photographs of ecosystems in North America and match them with data cards giving the rainfall, seasons, and types of plants in each ecosystem. The invention part consists of your naming the ecosystems.

Identifying ecosystems. Tell your students that they are to investigate various types of ecosystems on the North American continent, using the ecosystem photographs in conjunction with the information on the data cards. They are to identify each pictured ecosystem.

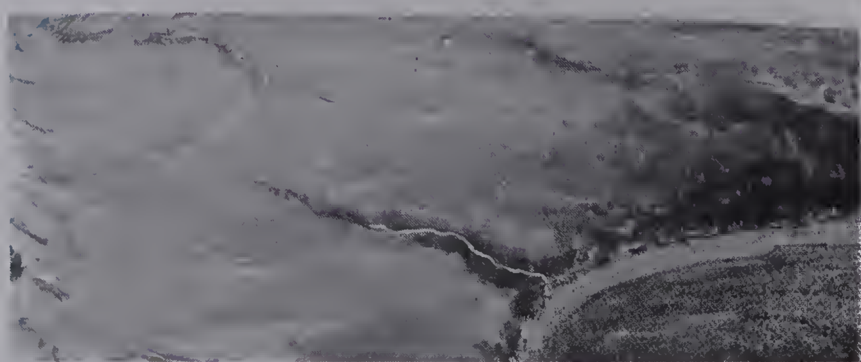
Figure 17–1. Matching the photo and data card for one ecosystem.

Normal Annual Precipitation in Centimeters

Alabama, Birmingham	135.2	California, Mt. Shasta	95.2
Alaska, Fairbanks	28.5	Colorado, Denver	39.4
Alberta, Edmonton	44.0	Connecticut, Hartford	110.2
Arizona, Phoenix	17.9	Delaware, Wilmington	117.5
Arkansas, Little Rock	123.2	Florida, Orlando	130.1
British Columbia, Vancouver	149.0	Florida, Miami	151.9
California, Los Angeles	35.7	Georgia, Atlanta	122.8
California, San Diego	24.0	Hawaii, Hilo	339.3
California, San Francisco	52.5	Idaho, Boise	29.2
California, Sacramento	43.7	Illinois, Chicago	80.6



Indiana, Indianapolis	98.4	Minnesota, Minneapolis	65.9
Iowa, Des Moines	78.4	Mississippi, Jackson	124.9
Kansas, Wichita	77.7	Missouri, Columbia	95.0
Kentucky, Louisville	109.5	Montana, Helena	28.9
Louisiana, Baton Rouge	137.3	Nebraska, Lincoln	67.7
Maine, Portland	103.6	Nevada, Reno	18.3
Manitoba, Winnipeg	51.6	New Hampshire, Concord	91.9
Maryland, Baltimore	102.8	New Jersey, Newark	105.3
Massachusetts, Boston	108.0	New Mexico, Albuquerque	19.7
Michigan, Lansing	77.2	New York, New York	102.1



North Carolina, Raleigh	108.1	Tennessee, Nashville	116.8
North Dakota, Bismarck	41.0	Texas, Austin	82.5
Ohio, Columbus	94.0	Texas, El Paso	19.7
Oklahoma, Oklahoma City	79.7	Utah, Salt Lake City	38.5
Ontario, Toronto	81.8	Vermont, Burlington	82.7
Oregon, Eugene	108.1	Virginia, Richmond	108.2
Oregon, Burns	30.0	Washington, Seattle	90.6
Pennsylvania, Harrisburg	92.6	Washington, Yakima	20.3
Quebec, Montreal	103.3	Puerto Rico, San Juan	150.2
Rhode Island, Providence	108.6	West Virginia, Parkersburg	97.6
South Carolina, Columbia	117.8	Wisconsin, Milwaukee	73.8
South Dakota, Rapid City	43.5	Wyoming, Lander	35.2

Most of the information above was furnished by the National Oceanic and Atmospheric Administration (NOAA).

Divide your class into four teams. Hand out one set of photographs and one set of data cards to each team. Explain that each data card contains the name of one of the ecosystems, the major kinds of plants that grow there, the annual *precipitation* (rainfall and snowfall), and the nature of the seasons.

Ask the children to use the data on the data cards to identify the ecosystems shown in each picture. After the students have made their identifications, hold up each picture in turn and ask them to name the ecosystem.

Your ecosystem. Student manual pages 26–28. Ask the children to identify the ecosystem in which they live. To do this, they can use the data cards as well as their own information about the major plant types that grow in their area. In addition, they will need information on annual precipitation in major cities of the United States and Canada. This can be found on pages 26–28 in their student manuals.

Discuss with the children what evidence they used to identify their own ecosystem.

Figure 17–2. Using the first map.

North American Ecosystems maps. Using tape, post Map 1, which shows the major ecosystems in the North American continent and in Hawaii. With the aid of the children, use the colored legend to identify the area of each ecosystem.

- Now post Map 2, showing outlines of the states and Canadian provinces.
- Ask the children to identify the ecosystem or ecosystems in your area. Does the information support their earlier identification of their own ecosystem?
- Discuss with the children the possible reasons for the distribution of the ecosystems.
- Remind them that precipitation and temperature are the two major factors determining the nature of the ecosystem. Can they explain why there is a difference in precipitation in different areas?
- After the children have exhausted their ideas, show them Map 3, showing the mountain ranges and the direction of prevailing winds.
- Point out the mountain ranges and the arrows indicating the prevailing winds moving from west to east. (In Hawaii the prevailing winds flow from the east.)
- Ask the students if the mountain ranges may have anything to do with the location of the deserts and the grasslands.
- If the children have no ideas, explain that the air picks up moisture from the Pacific Ocean and forms clouds. When the air rises over the mountains, rain and snow fall, especially on the western slopes. As the winds pass over the mountains, most of the moisture is lost, and so very little is left to fall on the land east of the mountains.

Figure 17–3. Identifying your ecosystem with the aid of the second map.

- After discussing the effect of the mountains, ask the children if they can explain why the eastern half of the United States has enough precipitation (about 100 cm, or 40 in, a year) to support the growth of the deciduous forest.
- If no one notices the arrows showing the prevailing winds moving from the Gulf of Mexico across the eastern half of the United States, you should do so. Ask where these winds pick up their moisture.

Figure 17–4. Mountain ranges and prevailing winds are shown on the third map.

OPTIONAL ACTIVITIES

Ecosystems and animals. Just as the plants in various ecosystems must have certain characteristics to survive there, so must the animals. Your students may be interested in researching the traits of animals that are associated with only one or two ecosystems, such as ptarmigan (tundra), moose (taiga), woodpeckers (deciduous forest), parrots (tropical rain forest), bison (grassland), scrub jays (scrub forest), and yucca moths (desert). Remind the children that the animals must be adapted both to live in the physical environment of the ecosystem and to feed on the plants or on the other animals found there.

Cleanup. Collect all the pictures and data cards and return them to the kit. Leave the maps on the wall until you have finished Chapter 18.

18 Ecosystems and Humans

SYNOPSIS

The children discuss how humans have changed natural ecosystems.

Suggested time: *one session to begin, followed by a short session a week later, with intermittent cutting and pasting during the week*

TEACHING MATERIALS

For each child:

student manual pages 29 and 30

For the class:

Cycles in an Ecosystem chart (from Chapter 16)
paste or tape*
felt pen or crayon*
butcher paper*

* provided by the teacher

TEACHING SUGGESTIONS

In this activity the children see ways in which natural ecosystems have been modified; this begins the discovery phase of the learning cycle for ecosystems.

Modified ecosystems. Student manual pages 29 and 30. The pictures on these pages show how humans have modified some natural ecosystems. Ask the children to identify each type of ecosystem shown and to point out what changes have been made by humans.

If your pupils have difficulty, discuss with the children that humans (1) have cut the trees in coniferous forests for lumber, (2) have cleared trees from areas in the deciduous forest to build farms, (3) have plowed up grasslands to build farms, (4) have irrigated the desert to grow crops. Then ask the children to identify the pictures that show these changes.

Two of the pictures show erosion that has occurred as a result of (5) removing trees from a deciduous forest, and (6) plowing up the soil of a grassland. Ask the children to identify these pictures. Explain that when trees or grass are removed there are no roots to retain the soil, and so the water runs off, carrying the soil with it.

Inquire about your own ecosystem. Do they know of any changes in the natural ecosystem that have been the result of human activity?

Look at the pictures on this page and on page 30.
In what ecosystem do you think each picture was taken?
What changes in the original ecosystem have been made by humans?

1.

2.

3.

Some of their answers will involve large buildings, parking lots, and other features of urban or suburban areas.

City ecosystems. Any city is located in a natural ecosystem. To begin this activity, post the Cycles in an Ecosystem chart you prepared in Chapter 16. Say that cities must fit into these cycles because the humans and other organisms in cities are still dependent on natural cycles—but that humans have added many things to the environment, such as buildings and cars, and subtracted other things, such as forests and predators.

Using the chart, briefly review the structure of a natural ecosystem—a community of producers, consumers, and decomposers interacting with environmental factors that include precipitation, heat, light, soil, minerals, and air.

- Now point to the consumers on the chart and say, "In our natural ecosystem, the deciduous forest (or whatever ecosystem you are in), many other consumers compete with us. What competitors do we have in cities?"
- The children should realize that such large competitors as foxes and bears have been driven out of urban areas and that we use window screens, insecticides, antibiotics, and refrigerators to shield ourselves and our food supplies from small competitors such as cockroaches and the decomposers. Start a concise list of the things mentioned.
- Pointing to the Decomposers section, ask how humans in cities have modified the breakdown of wastes. Bring out suggestions about garbage disposals, landfill projects, toilets, and sewers.
- Similarly, encourage suggestions about human management of basic food chains—transportation of food from surrounding farms or from distant areas, preparation and storage of food, and so on.
- Indicating the environmental factors on the chart, ask where city water comes from, how we control the amount of light and heat in daytime and nighttime, how we protect ourselves from bad weather, and how we provide fresh air in large buildings and tunnels. Each question should bring forth more suggestions of machinery and engineering.
- When it is obvious to the children that the city ecosystem is extremely complex and crowded with human inventions, ask where the energy for the appliances, vehicles, and buildings comes from. This will lead to a list of utilities needed for supplying energy and providing communication among the people who are participating in the life of the city.
- Finally, ask the children to construct a mural depicting Metro City, an imaginary city in your own ecosystem. As shown in Figure 18-2, the outer circle of the mural, which has no real geographic limit, is the natural ecosystem. This merges into farms or ranches, then into small towns and suburbs. The next circle is the city, and the "bull's-eye" is a home. (Depending on your own students' homes, this could be a single-family home

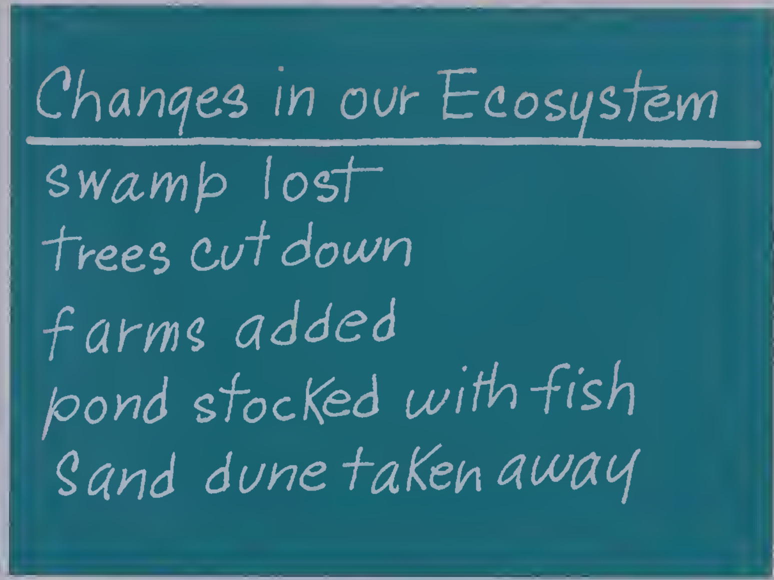


Figure 18–1. Changes produced by humans in one ecosystem.

Figure 18–2. One Metro City mural.

or an apartment building. It should be familiar to the children, so that they can easily suggest additions to the mural.)

- In each circle of the mural, have the students paste or tape pictures having to do with human ecological needs. Do not restrict the children's ideas except to see that the pictures are placed in logical places on the mural and that the children understand how each picture relates to the basic Cycles in an Ecosystem chart. For example, if a child adds a picture of a widget factory, ask if the widget affects food preparation, control of water quality, or what.
- Allow the children to crowd pictures and overlay them when it becomes necessary. This will help emphasize the point that the natural ecosystem usually becomes more and more artificial as you move to the center of a city. It may also bring out comments about pollution, which will be studied further in Part Five.

Discussion. When the mural is completed, ask the children what natural ecosystem Metro City is located in. After they reply, say, "A sixth-grade class in (some other ecosystem) is also making a mural like this one. What do you think their mural looks like?" The chil-

dren should be able to suggest differences in the outer edges of the mural, but it will be difficult for them to come up with differences in Metro City itself. The artificial ecosystems created by humans, whatever their geographic differences, have a monotonous similarity.

OPTIONAL ACTIVITIES

Smaller pictures. If the children want to focus on specific parts of the class mural, you might want to have different individuals or groups do collages illustrating the structures and activities associated with nutrition, education, waste treatment, medical care, or any other topics of interest. Old journals used by (and with permission of) parents in medicine or engineering, as well as your own old education journals, are good sources of pictures. Encourage the children to see that education, for example, contributes to survival of individuals and populations and helps humans to make decisions about protecting basic interactions between community and environment. However, this activity should be as abstract or concrete as is appropriate for your children.

Varying Metro Cities. Especially if your children seemed discouraged about urban life after the discussion of the mural, you may want to encourage them to think about how cities can again be related to their natural ecosystems through imaginative planning. If your nearest natural history museum or zoo has special exhibits relating to the local ecosystem, consider a field trip there. Libraries, art museums, scientific societies, universities and colleges are other places you might visit or from which you can get information. Civic groups are often helpful. The children might enjoy planning on paper, or even helping to set up, a vest-pocket park near the school, where the natural ecosystem could be seen again.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concept of cycles in an ecosystem, turn to page 99 of the evaluation section at the back of the guide.

Part Five

Pollution

OBJECTIVES

To use the term* pollution *to refer to adding a substance to an ecosystem in a quantity harmful to organisms.

To describe the effect of pollution on the structure of a biotic community.

To identify some sources of pollution in an ecosystem.

BACKGROUND INFORMATION

Pollution has become a popular term used to refer to a variety of ecological problems created by humans. As the term has become increasingly familiar and more and more problems have become evident, its meaning has broadened to include any unpleasant environmental situation. We are all familiar with "air pollution," "water pollution," "thermal pollution," "noise pollution," and "oil pollution."

Our primary concern in this Part will be with pollution that is the result of relatively gradual ecological changes brought about by our continued addition of certain materials (called pollutants) to the environment. An important aspect of this kind of pollution is that the detrimental effects are often not obvious until much damage has been done. Often, several apparently unrelated factors interact, producing slow environmental changes. The final result can be such a drastic change in the structure of the ecosystem that no amount of effort can reclaim what was originally there.

Many kinds of water pollution result in lowering the amount of oxygen in the water. In any ecosystem the amount of oxygen is a critical factor in the lives of all the animals in the community. Oxygen does not dissolve as readily in water as do many other gases (such as carbon dioxide), and even under ideal conditions, there is usually less oxygen available to water animals than to land animals. Because of this, oxygen is one of the main factors limiting the size and complexity of any aquatic community.

The amount of oxygen depends partly on how much decomposition is taking place. The decomposers are an important part of every community: these organisms use nonliving organic matter (such as dead organisms and waste products) as food, leaving inorganic raw materials (minerals) that are usable by green plants. During this process the decomposers use oxygen and give off carbon dioxide. This results in competition for available oxygen between the decomposers and the animals in an aquatic community.

Normally, the numerous interactions within an ecosystem tend to maintain the various populations in what can be considered a balanced state. However, the problems in our lakes today result primarily from oxygen-deficient water. This oxygen deficiency is apparently due to the tremendous increase in decomposers. This increase, in turn, is the result of a drastic increase in the food for decomposers—nonliving organic matter.

There are two basic, seemingly unrelated causes for the overabundance of organic matter. First is the organic matter added to a lake in the form of human sewage. (Even treated sewage can cause problems, because most treatment plants release minerals that aid growth and reproduction of aquatic plants.)

The second, more important source of organic matter is periodic "blooms" of algae, which appear when great quantities of fertilizer are washed into rivers and streams from surrounding farmlands. Commercial fertilizers consist of inorganic raw materials essential for plant growth; algae, like all green plants, combine these minerals with the food they have made from air and water, making new organic substances. An algal bloom appears quickly, and it dies equally fast, providing more organic matter that serves as food for oxygen-consuming decomposers.

In addition, some decomposers can even grow and reproduce *without* oxygen when necessary, which adds to the mass of organic matter present. When decomposers themselves die, they provide food for still more decomposers.

Unfortunately, the sequence does not stop there, for decomposition releases more inorganic minerals, and these serve as additional fertilizer for future algal blooms. Thus, there is a cycle involving periodic algal blooms which can result in excess carbon dioxide and a lack of available oxygen for animals living in the community.

Figure V–1. An algal bloom.

The result of this sequence is not the dead lake that you might expect; it is an ecosystem in which the community has been reduced in complexity. Instead of the typical producer-consumer-decomposer relationship found in most aquatic communities (consisting of many kinds of green plants, fish, insects, microorganisms, and so on), the lake now contains mostly algae, decomposers, and a huge mass of decaying organic matter.

The substances that would be considered the pollutants in this process are organic material (sewage and dead algae) and inorganic raw materials (fertilizer), which are normal parts of an ecosystem. The problems arise only when these are present in amounts large enough to disrupt the normal processes of the lake ecosystem. For this reason, we don't restrict the term pollutant only to unnatural substances (such as pesticides and tin cans), but use it to include any substances added to an ecosystem in a quantity that disrupts the existing balance among organisms.

We have found that children often consider pollution only in terms of the visible by-products of a technological society, such as tin cans on a hillside or smog over a city. We hope that as a result of the activities in this Part children will begin thinking in terms of how pollution can change the structure of an entire ecosystem. To encourage this change in thinking, you are asked in each activity to refer to the Cycles in an Ecosystem chart, pointing out the particular cycle involved in the experiment and discussing with the children the possible effects that altering this cycle would have on the rest of the ecosystem.

In each activity, students consider one aspect of the pollution sequence that produces drastic changes in aquatic ecosystems.

OVERVIEW

The activities in Part Five are intended to simulate events that can result in the pollution of a lake or pond. In Chapter 19, " 'Inventing' Pollution," the terms pollutant and pollution are introduced after the children see how fish respond to excess carbon dioxide. As a result of investigating the effect of excess food in a system in Chapter 20, "Food as a Pollutant," the children consider the response of decomposer populations to excess organic matter. In Chapter 21, "Algae and Fertilizer," they investigate the effect of excess commercial fertilizer on algae populations. Experiments in Chapter 22, "Keeping Track of Fertilizer," involve the movement of fertilizer through the soil.

GETTING READY
You will need several liters of aged tap water for the activities in Part Five.

19 "Inventing" Pollution

SYNOPSIS

The children investigate the response of guppies to excess carbon dioxide.

The term **pollution** *is introduced.*

Suggested time: *one class session*

TEACHING MATERIALS

For each child:

student manual page 31

For each team of four children:

2 guppies

Drawer 3

1 green adhesive dot
1 dip net

Drawer 4

2 tumblers
3 vials

Drawer 5

1 vial cap with hole
1 plastic tube

For the class:

Cycles in an Ecosystem chart (from Chapter 16)
aged tap water*
paper towels*

Drawer 3

1 package seltzer tablets

Drawer 4

pitcher
tumbler
vial

Drawer 5

3 bottles BTB
plastic tube
vial cap with hole

* provided by the teacher

ADVANCE PREPARATION

Each team will need two guppies, one for the experimental vial and one for the control vial. Provide each team with a tumbler containing one-fourth tumbler of aged tap water and two guppies. (If there are not enough fish, only a few teams should set up control vials. The other teams can compare the fish in the experimental vials to those in the control vials.)

TEACHING SUGGESTIONS

This is an exploration activity. The children investigate the effect of too much of a naturally occurring substance (carbon dioxide) on guppies. The terms pollutant and pollution are introduced.

Post the Cycles in an Ecosystem chart and briefly review the cycles pictured there. Explain to the students that they will do an experiment in which they alter one cycle. Indicate the oxygen–carbon dioxide cycle, and tell the children that they will determine the effect of excess carbon dioxide on an organism.

Testing the effect of excess carbon dioxide. A way to test the effect of excess carbon dioxide on animals is to bubble the gas (from a seltzer tablet) through water, add a fish to the water, and compare the behavior of this fish to the behavior of one in plain water. However, it is necessary to demonstrate first that the gas produced by seltzer tablets actually is carbon dioxide.

Demonstrating the seltzer gas generator. A gas generator is prepared as follows:

1. Use a plastic cup about half-filled with water and a vial one-quarter-filled with water.
2. Insert a plastic tube about 6 mm (¼ in) through the hole in the vial cap.
3. Drop one seltzer tablet into the vial of water and snap the cap on the vial. (The open end of the tube should not touch the water.)

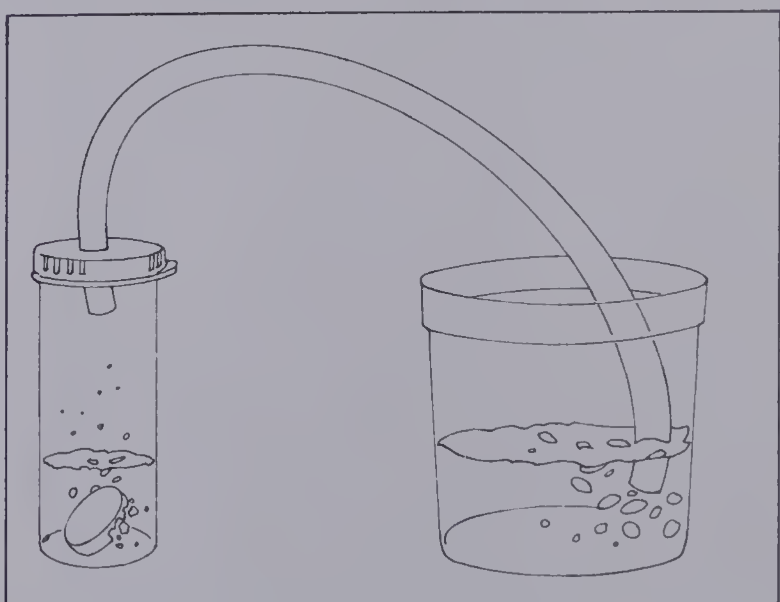


Figure 19–1. A gas generator.

Ask your students what is happening to the tablet. They should be aware that the tablet is bubbling as it dissolves. Now place the other end of the plastic tube in the cup of water. When the children see gas bubbling through the water in the cup, ask them how they might test whether the gas contains carbon dioxide. If they do not suggest using BTB, you should do so.

Have the children pick up the materials they will need and set up their own generators. One member of each team should add twelve drops of BTB to the water in the cup while another sets up the rest of the equipment. In very little time the children will observe that gas from the tablets interacts with BTB.

Discussion. After the children have observed the results, ask them questions similar to these:

- What kind of gas do the tablets produce?
- What evidence did you use to identify the gas?

Also ask the children to compare the results of blowing through blue BTB with the results of bubbling gas from seltzer tablets through it.

Carrying out the experiment. The contents of the vials and cups should be discarded and the vials and cups rinsed. Have the children reassemble their gas generators but not add seltzer tablets. Then have them follow this procedure:

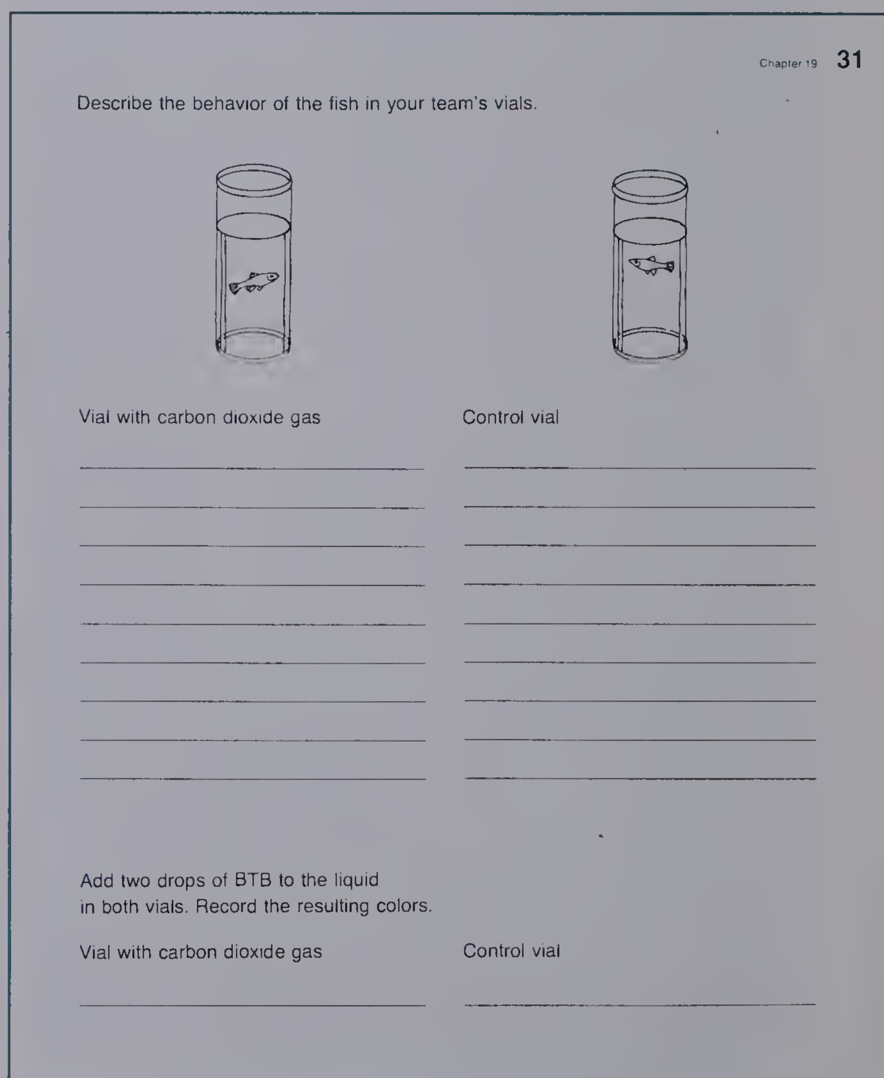
- Prepare two vials of plain aquarium water.
- Place two seltzer tablets in a generator vial, snap on the cap, and place the free end of the plastic tube in one of the vials of aquarium water. Place a green dot on this vial to label it.
- Immediately add one fish to each vial of aquarium water. To do this, empty the tumbler containing both fish into a net held above another tumbler until a fish is caught, then drop the fish into the desired vial by inverting the net over the vial.

Figure 19–2. Have the fish ready to add to the vial.

Observing the results. Student manual page 31. Tell the teams to observe the behavior of the fish in both the experimental and control vials. Some of the students will observe that fish in the experimental vials swim upside down or sink to the bottom. Explain that a fish can survive at least five minutes after this occurs, so there is no need for panic. Suggest that the students test the liquid in their experimental and control vials with BTB. They should add two drops to each vial (BTB will not harm the fish).

As soon as teams complete the BTB tests, they should remove the fish from the vials. The children can pour the contents of the vials through the net into the empty cup and then invert the net over the cup containing the aged tap water. There they can observe the behavior of the fish for a few minutes before returning them to the aquariums. The children should record their experimental results in the student manual.

"Inventing" ***pollution.*** Ask the children if they observed any difference between the two vials before


Chapter 19 31

Describe the behavior of the fish in your team's vials.

Vial with carbon dioxide gas

Control vial

Add two drops of BTB to the liquid in both vials. Record the resulting colors.

Vial with carbon dioxide gas

Control vial

adding the fish. What differences were there in the behavior of the experimental and control fish? What could have caused these differences? Ask the children to explain how carbon dioxide can be harmful even though it occurs naturally. A student may point out that much more carbon dioxide was added to the experimental vials than would normally accumulate. Tell the children that the addition of a substance to an ecosystem, in a quantity large enough to harm organisms, is called *pollution*. The substance itself is called a *pollutant*.

Ask the children how they could find out whether a lake contained a harmful excess of carbon dioxide. They will probably suggest that BTB tests would be necessary to determine if enough carbon dioxide were present to be considered a pollutant.

It is hoped that with this kind of discussion the children will arrive at the conclusion that pollutants are not always visible and that tests may be necessary to determine their presence.

Refer to the oxygen–carbon dioxide cycle on the chart. Ask the children what would happen in a natural aquatic ecosystem, such as a lake, if the amount of carbon dioxide were greatly increased.

Ask the children to name other substances that might become pollutants and to suggest situations in which they would become pollutants. If no one suggests food or garbage, use the ensuing discussion as an introduction to the next chapter.

Cleanup. All the equipment should be rinsed thoroughly and returned to the kit. Refill the aged tap water container for use in the next chapter.

Figure 19–4. Returning the fish to the tumbler.

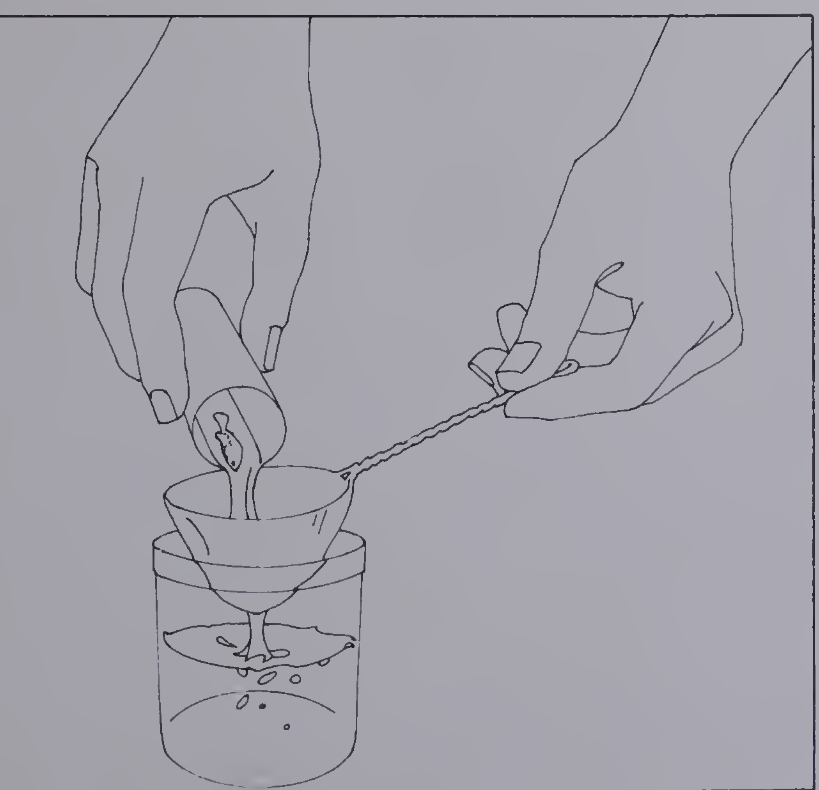
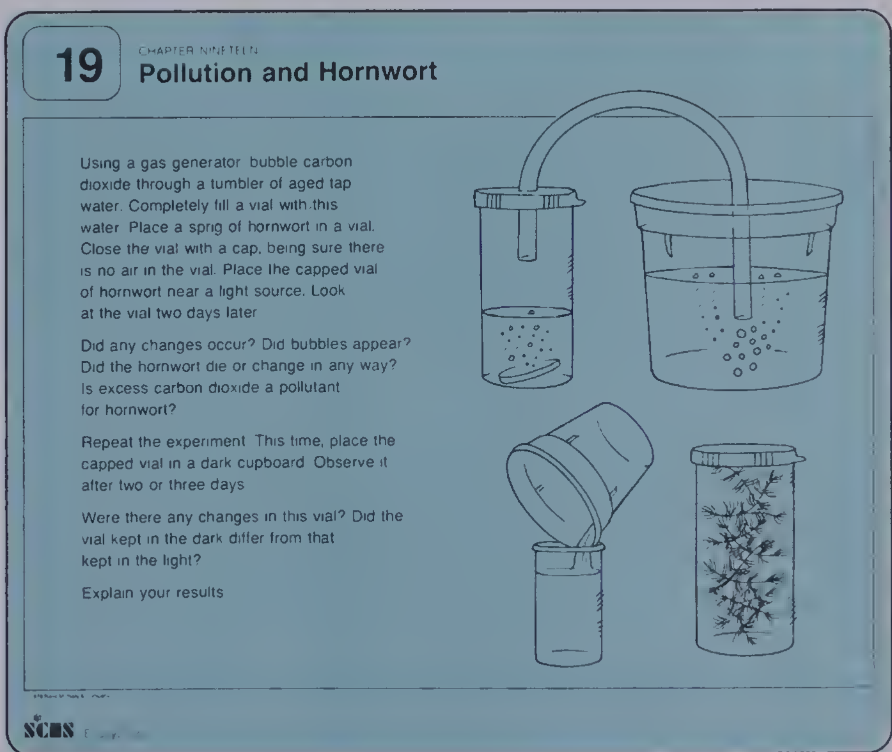


Figure 19–3. Adding BTB to the liquid in the vials.

EXTENDING YOUR EXPERIENCE CARD

19. Pollution and Hornwort. Children experiment to discover the effect of excess carbon dioxide on hornwort. They will need a gas generator, a tumbler, one vial with cap, one light source, a dark cupboard, and hornwort.



19 CHAPTER NINETEEN

Pollution and Hornwort

Using a gas generator bubble carbon dioxide through a tumbler of aged tap water. Completely fill a vial with this water. Place a sprig of hornwort in a vial. Close the vial with a cap, being sure there is no air in the vial. Place the capped vial of hornwort near a light source. Look at the vial two days later

Did any changes occur? Did bubbles appear? Did the hornwort die or change in any way? Is excess carbon dioxide a pollutant for hornwort?

Repeat the experiment. This time, place the capped vial in a dark cupboard. Observe it after two or three days

Were there any changes in this vial? Did the vial kept in the dark differ from that kept in the light?

Explain your results

SCIIS

20 Food as a Pollutant

SYNOPSIS

The children add various amounts of food to small aquatic systems.

They observe that the systems containing large amounts of food show evidence of decomposition and excess carbon dioxide.

The term **organic matter** *is introduced.*

Suggested time: *two class sessions*

TEACHING MATERIALS

For each child:

student manual page 32

For each team of four children:

4 snails

Drawer 3

1 medicine dropper

Drawer 4

5 tumblers
6 vials

For the class:

fish food pellets
Cycles in an Ecosystem chart (from Chapter 16)

Drawer 5

3 bottles BTB

ADVANCE PREPARATION

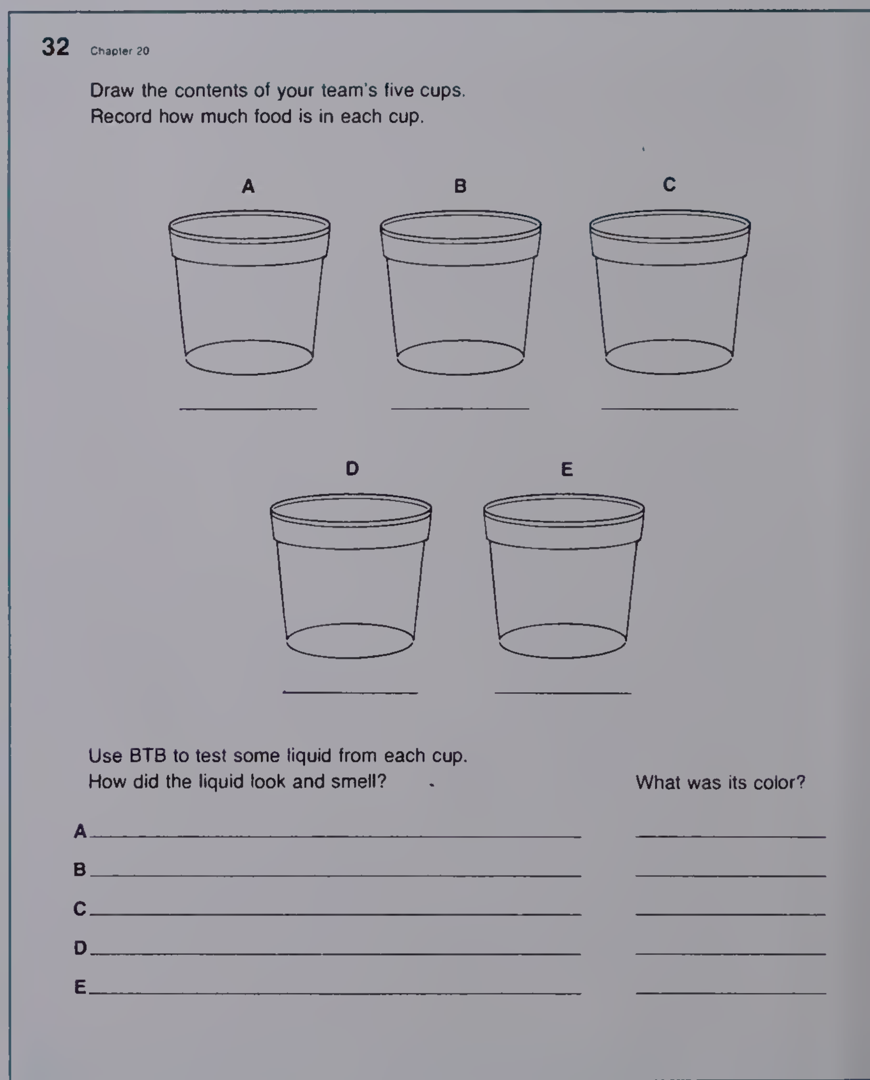
Prepare several distribution centers from which teams can obtain the materials. The snails can be removed from the aquariums and placed in tumblers at each distribution center (only small amounts of water need be added to these tumblers).

TEACHING SUGGESTIONS

This is a discovery and invention activity that demonstrates that food, essential for the life of snails, can be detrimental if present in too great a quantity. The term organic matter is "invented."

Refer to the Cycles in an Ecosystem chart. Review the way the children changed the oxygen–carbon dioxide cycle in the previous chapter. Then explain that they will now alter another cycle. Indicate the word Food between Producers and Consumers in the food-mineral cycle. Explain that in this experiment different amounts of food will be added to small aquatic systems containing snails.

The experiment. Student manual page 32 (top). Sketch the accompanying diagram on the chalkboard to illustrate the setup. Point out that three of the tumblers contain a snail and food. The other two will serve as controls—one with a snail alone and one


32 Chapter 20

Draw the contents of your team's five cups.
Record how much food is in each cup.

A B C D E

Use BTB to test some liquid from each cup.
How did the liquid look and smell? What was its color?

A ____________ ____________
B ____________ ____________
C ____________ ____________
D ____________ ____________
E ____________ ____________

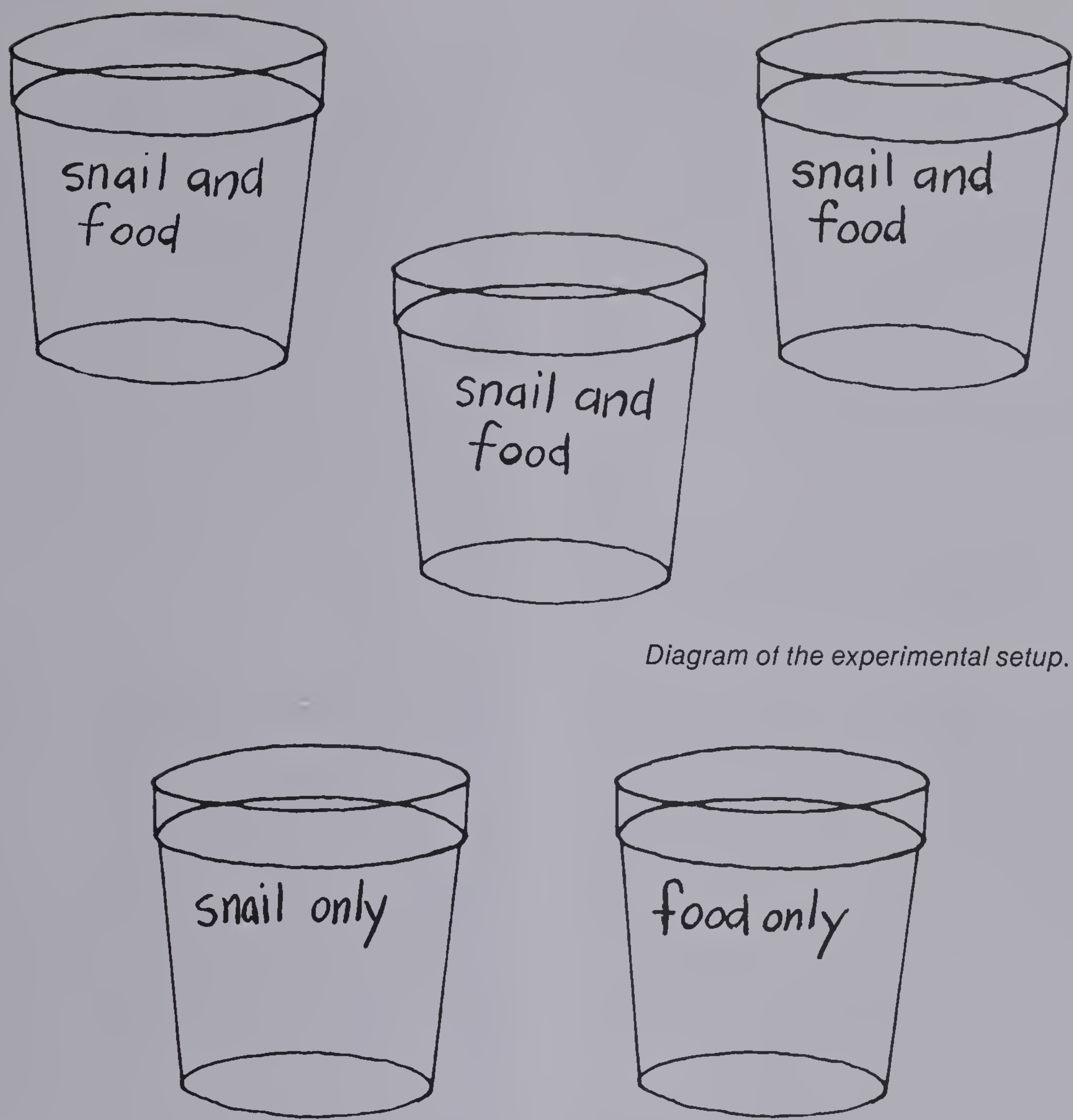


Figure 20–1. Diagram of the experimental setup.

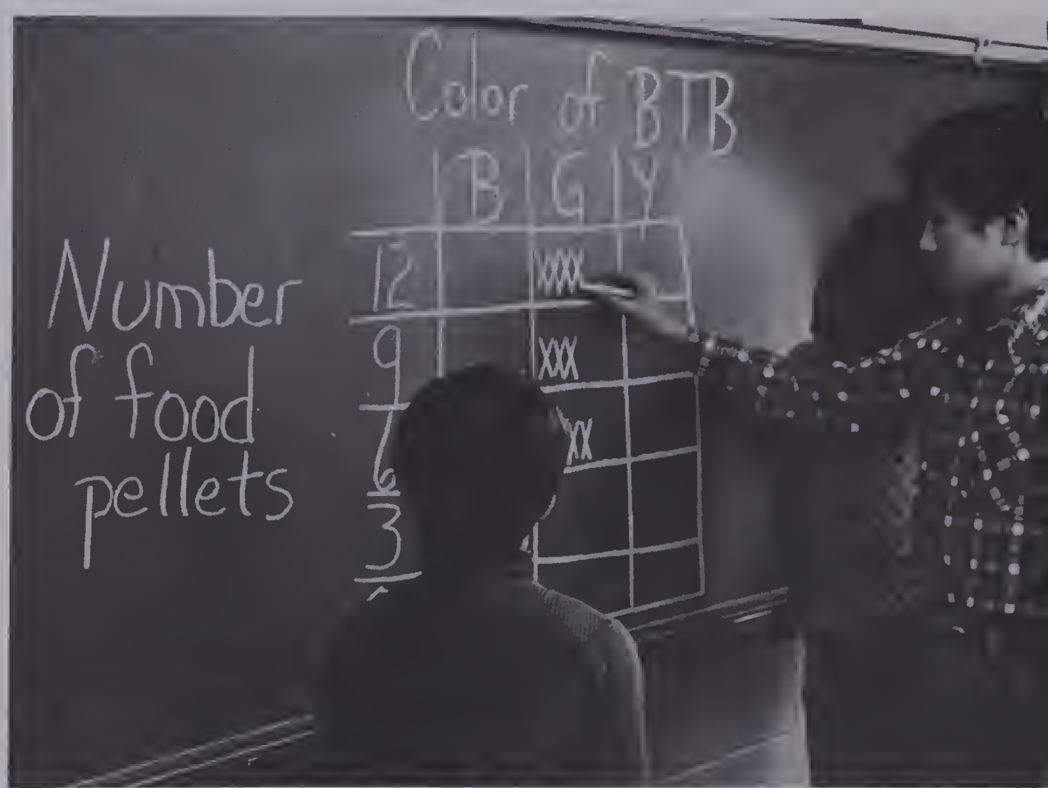
with food alone. By comparing the results the children can determine if excess food could be a pollutant.

The children should obtain their materials and half-fill their tumblers with aged tap water. Tell them that the amounts of food they add should differ. Teams may decide the quantities of food they will add or you may prefer to assign the amounts to be used. Either way, a team should test different amounts of food in three tumblers containing snails. For example, a team could use one, three, and six pellets; the setup containing food alone should contain the intermediate amount (three pellets).

Each tumbler is labeled with the team members' names or initials and the quantity of food added. The children can record the team's experiment at the top of page 32.

The results. Student manual page 32 (bottom). When someone reports that the water has become cloudy or has a foul odor (usually in two or three days), have the

Figure 20–2. Recording the results.



teams observe their systems to see what changes have occurred. Give each team six vials and suggest that BTB be used to test water samples from the tumblers.

You might demonstrate how to transfer water from a tumbler to a vial with a medicine dropper (be careful not to include any of the food) and add a few drops of BTB to each vial. Suggest also that the teams compare the color of the solutions in the vials with that of plain aged water and BTB.

Have the children record their results at the bottom of page 32. You might also find it helpful to construct a class record similar to that illustrated.

Discussion. Ask the children to describe differences in odor and appearance among the setups. Students who have studied the *Communities* unit may recall that a foul odor is evidence of the presence of bacteria.

Remind the class that bacteria are decomposers which live on animal wastes and on the bodies of dead organisms. Also remind the students that the bodies of both plants and animals are constructed from food that was originally produced by green plants. Thus the bodies of both plants and animals contain a special material found only in living and dead organisms. This special material is called *organic matter.* In addition to other elements, organic matter always contains carbon. The food used in these experiments also contained organic matter. Explain that decomposers use oxygen as they digest organic matter and that they release carbon dioxide into the water. Did the results of the BTB tests indicate the presence of excess carbon dioxide? Where might it have come from?

Cycles in an Ecosystem chart. Ask your students to indicate which cycle on the chart was altered in this experiment and at what point. They should state that the food-mineral cycle was altered at the point when food was provided for consumers (snails). Then ask them to explain what effect adding food at this point would have on the rest of the ecosystem. The ensuing discussion should bring out the following points:

- Excess food results in the increased action of decomposers (indicated by the odor).
- Decomposers produce carbon dioxide (indicated by BTB tests).
- As the amount of food increases, the amount of carbon dioxide produced by the decomposers also increases.

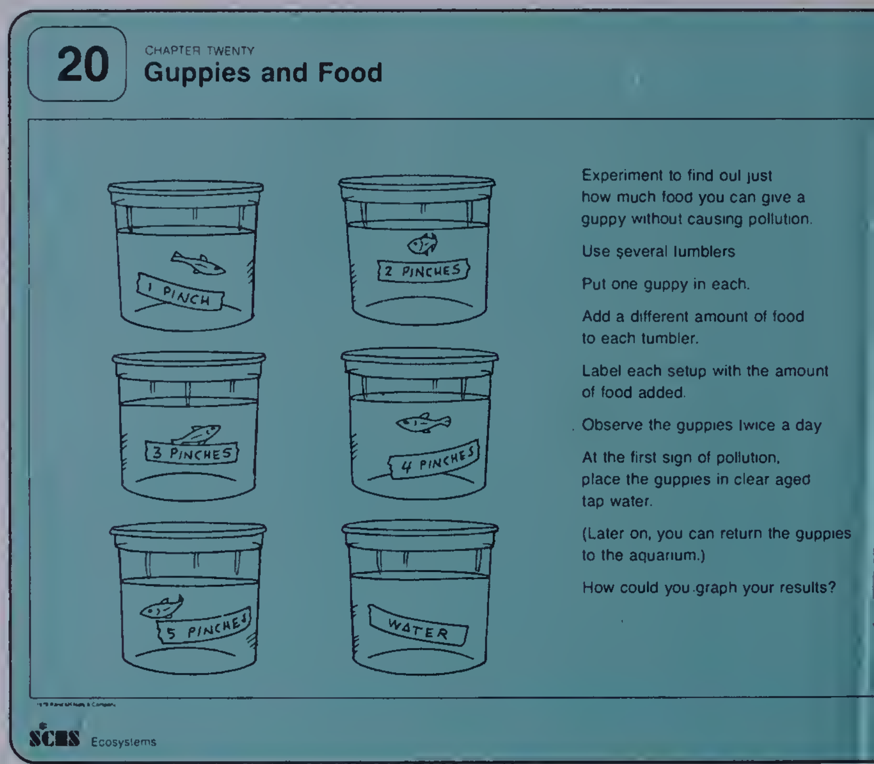
Explain that since decomposers produce carbon dioxide and use oxygen as they decompose organic matter, the increase of carbon dioxide means there is a decrease in oxygen.

Remind the class about its experiments in which they found that excess carbon dioxide is harmful to guppies. Then ask what might happen if excess food (or other organic matter) is added to a stream, lake, or pond.

Cleanup. Discard dead snails and return the rest to the aquariums. Wash the tumblers and vials in a mild soap solution and rinse thoroughly before returning them to the kit. Refill the containers of aged tap water for use in the next chapter.

EXTENDING YOUR EXPERIENCE CARD

20. Guppies and Food. Children experiment to discover how much food can be added to a plastic tumbler containing a guppy without causing pollution. They will need guppies, guppy food, tumblers, and aged tap water.



21 Algae and Fertilizer

SYNOPSIS

Children test the effect of commercial fertilizer on the growth of algae.

They relate the resulting algal bloom to the decomposition of excess organic matter.

Suggested time: ***three class periods***

TEACHING MATERIALS

For each team of four children:

Drawer 4

4 tumblers
1 vial

For the class:

algae culture
Cycles in an Ecosystem chart (from Chapter 16)

Drawer 2

2 light sources

Drawer 3

1 package fertilizer pellets

TEACHING SUGGESTIONS

This is a discovery activity that demonstrates another way in which an excess of a normal part of an ecosystem (minerals) can adversely affect that ecosystem.

Introducing the activity. Remind the children that a pollutant is any substance that, in large enough quantities, can harm organisms. Ask them to recall the effect of a large quantity of carbon dioxide on guppies and the effect of excess food on a small aquarium containing snails. Explain that they will now investigate what happens to a small aquarium when an excess of fertilizer (minerals) is added.

Refer to the Cycles in an Ecosystem chart. Indicate the food-mineral cycle and explain that they will alter this cycle again but in a different place. Point to the arrow from Minerals to Producers and tell the children that they will add materials at this point.

Ask your students to explain the function of commercial fertilizers. They should be aware that fertilizers are widely used to supply minerals to improve the growth of plants. Then ask what the effect of fertilizer would be on algal growth, and allow the children to discuss their ideas. (You may have to remind them that algae are green plants.)

The experiment. The children can work in teams of four. Each team should set up four systems containing different amounts of fertilizer, but similar quantities of algae. One tumbler should contain algae in water without fertilizer, and three should hold both algae and fertilizer. Each team should fill all four tumblers about two-thirds full with aged water before adding fertilizer to three of them.

You may prescribe the amounts of fertilizer all teams use (amounts of three, six, and twelve pellets usually produce good results) or suggest that different teams test various fertilizer concentrations. In the latter case, it is a good idea for at least two teams to test each series of concentrations. For example, two teams could use two, four, and six pellets; two other teams could use eight, ten, and twelve; and so on. This method would result in a range of concentrations that would indicate the minimum and maximum amounts of fertilizer that produce an algal bloom.

When the children have added fertilizer to the setups they should also add one-half vial of algae water from the classroom algae culture. Each tumbler should be labeled with the amount of fertilizer it contains, the date, and the initials of the team members.

All setups should be placed close to the light source. You might suggest that four teams share each light source and arrange their tumblers as shown in Figure 21-1. You may wish to review the necessity for controlling an experiment. Ask the children if the results would be valid if the setups were placed at different distances from the light source. They should rec-

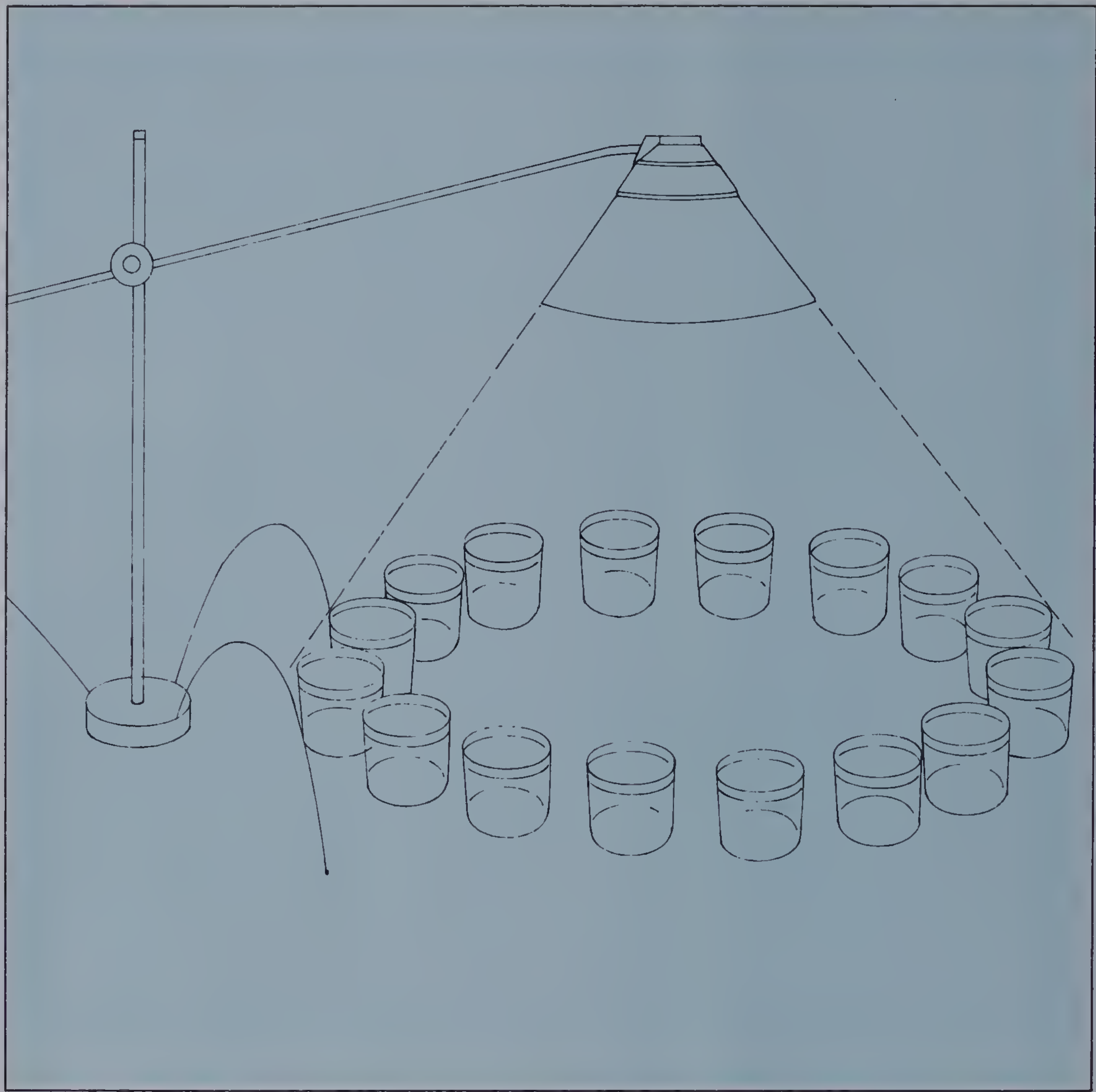


Figure 21–1. Making sure that all systems are lighted equally.

ognize that exposing the experiments to different amounts of light adds an additional variable.

Observations. Within about three days, the children should see algal growth, evidenced by increased "greenness," in some of the tumblers. Encourage them to predict which fertilizer concentrations will produce the most algal growth. Over the next week, have the children informally observe and discuss the experiments.

Discussion. You might draw a chart similar to the one illustrated on which to record the class data. Teams can record the results of their experiments by placing tally marks in the appropriate sections. When some children notice that a layer of dead algae is forming at the bottom of a cup, call this to the class's attention. Ask the children what they think will happen to the dead algae. Someone should suggest that the dead algae will decompose or rot. If no one makes this suggestion, refer to the dead algae as organic matter and ask what happens to all organic matter. Ask how decomposition would affect the concentrations of oxygen and carbon dioxide in the water. If the children hesitate to respond, remind them that decomposers use oxygen and produce carbon dioxide.

Cycles in a Ecosystem chart. Refer to the food-mineral cycle and review with your class how it was altered in the experiment. (Minerals were added.) Ask how the addition of minerals could affect an ecosystem. By the responses offered, you should be able to tell if your class understands the sequence of events caused by the addition of fertilizer:

1. Adding fertilizer results in an increase of algae, which becomes overpopulation, which causes more dead algae.
2. This organic matter serves as food for decomposers.
3. The increase in decomposers results in increased carbon dioxide and decreased oxygen.

Figure 21–2. Charting growth of algae with various amounts of fertilizer.

The children should also notice that the final results of adding fertilizer are the same as those of adding food.

At this point you may wish to elaborate on the definition for pollutant. Ask the children to name the pollutant in each experiment in the last three chapters. This discussion may bring out that in all experiments, one obvious result of altering a cycle was an excess of carbon dioxide. Some children may consider carbon dioxide as the pollutant in each case.

Remind them that a pollutant is any substance that is increased beyond the level that organisms can use or tolerate. Then ask what substances were increased in their experiments (carbon dioxide in the guppy experiment, food in the snail experiment, and fertilizer in this activity). Through this discussion the children should realize that excess carbon dioxide occurs as a result of increasing the amounts of certain materials in an aquatic ecosystem.

Cleanup. Discard the algae water. Wash the tumblers and vials in a mild soap solution and rinse thoroughly before returning them to the kit.

OPTIONAL ACTIVITY

Algae and BTB. Some children may wish to test their algae with BTB. Because fertilizer in the algae cultures may cause BTB to turn yellow before decomposition occurs, remove a sample of dead algae from the bottom of a tumbler and place it in a small amount of fresh water. After a few days the children can test this setup with BTB.

22 Keeping Track of Fertilizer

SYNOPSIS

The children set up soil-fertilizer systems.

They test soil samples with BTB and discover that fertilizer placed in one area can move to another.

Suggested time: ***four days***

TEACHING MATERIALS

For each team of four children:

Drawer 3

3 straws
7 labels
50 fertilizer pellets

Drawer 4

6 vials

Drawer 5

1 fluted container

For the class:

soil‡

Drawer 4

2 tumblers
4 water sprinklers

Drawer 5

3 bottles BTB

‡ Sand and Soil box

ADVANCE PREPARATION

For the first day's activities, set up distribution stations for the fluted containers, fertilizer pellets, soil, and rectangular labels. Plastic tumblers can be used as soil scoops. For the second day's activities, prepare a container of blue BTB solution, as directed on page 44.

TEACHING SUGGESTIONS

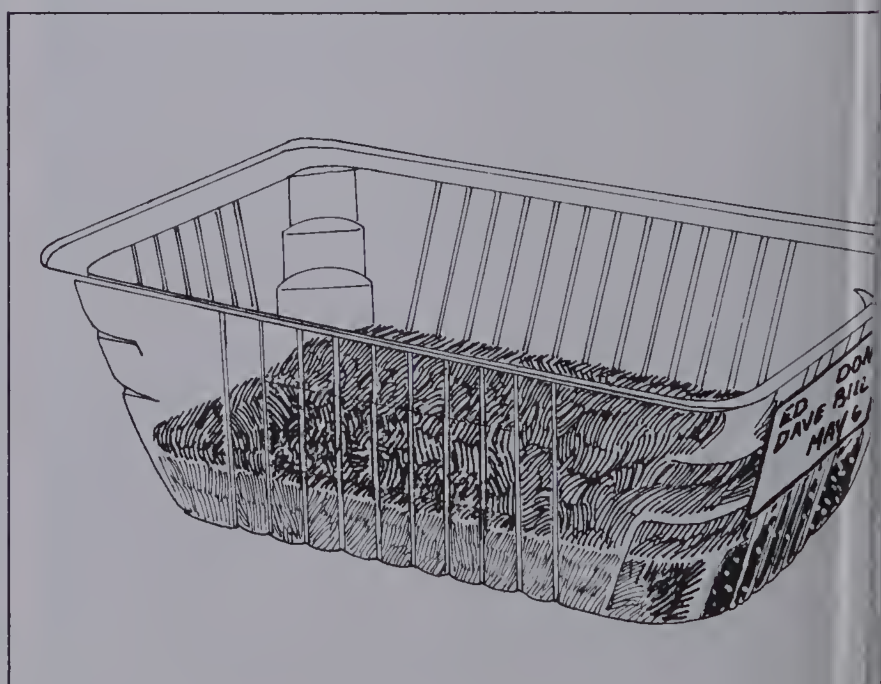
This is an exploratory activity in which the children investigate the movement of fertilizer through soil.

Asking the question. Ask the children what happens to fertilizer when it is placed on the soil around plants. They may suggest that it sinks into the soil, stays on the surface, dissolves, or goes into plants, for instance. Explain that BTB, which changes color in the presence of carbon dioxide, also reacts with the acids formed when fertilizer dissolves in water. You may wish to demonstrate this by adding a fertilizer pellet to a vial of BTB solution. Tell the children that they can use BTB to test for the presence of fertilizer in the soil.

Setting up the experiment. Tell the children that they will place pellets at one end of the container of soil. Then, after a few days, they will test the soil at various locations within the container.

Have them obtain their equipment, add soil to their plastic containers to a depth of about 2.5 cm (1 in), and moisten it well, but not to the point that water stands on the surface. They should place about fifty fertilizer pellets along one end of the container and cover them with a thin layer of soil. Finally, a label with the team members' names and the date should be placed at this end of the container.

Figure 22–1. One team's experiment.



Testing the soil. The containers should be watered daily. About three days later, the children should test the soil-fertilizer systems. At this time, each team will need six vials, three straws, BTB solution, and some labels.

Each team should fill its vials about one-quarter full with BTB solution. In order to set up a control, each team should first test soil containing no fertilizer. Suggest that the children use straws to remove a little soil from the classroom supply. They are to push the end of the straw a few millimeters into the soil and then lower the straw into the vial until the small soil plug falls into the BTB solution. This vial should be labeled *control*. It will show the color that can be expected from soil when no fertilizer is present.

Suggest that the teams place their vials next to the soil-fertilizer systems so that transfer of soil will be easier. The children should remove small amounts of soil from different locations in the container and place them in their vials. For example, the first sample could be taken from where the pellets were originally placed and subsequent samples could be taken at 50-mm (2-in) intervals along the length of the container. If fertilizer is present, the solution will change from blue to yellow. Each vial should be labeled with the appropriate distance from the fertilizer source from which the soil sample was taken. Tell the children to use a clean end of a straw for each soil sample, so that soil remaining from a previous test will not influence the results.

Discussion. Encourage a class discussion of the experiment. Try to restrict the initial discussion to fertilizer movement based on evidence from the experiment. Then ask for conclusions and inferences that may be made from the data. Questions such as the following may help:

- Does fertilizer stay in one spot or does it move through soil?
- What would you expect to occur if a field near a river or lake were heavily fertilized?

OPTIONAL ACTIVITY

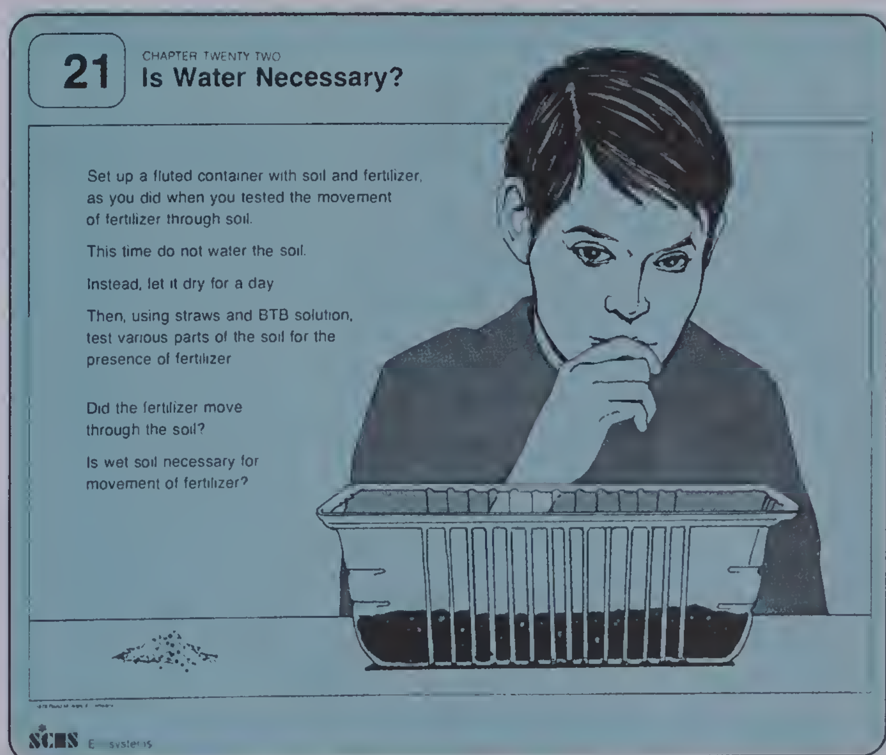
Erosion. Have the children test to find out whether flooding the original test container distributes the fertilizer faster. Where does the fertilizer go: to the soil surface, to the bottom of the container, or somewhere in between?

Cleanup. The soil should be discarded and other equipment should be washed in a mild soap solution, rinsed thoroughly, and returned to the kit.

Figure 22–2. Adding soil samples to the vials.

EXTENDING YOUR EXPERIENCE CARDS

21. Is Water Necessary? Children experiment to find out if the movement of fertilizer through soil depends on water being in the soil. A fluted container, soil, fertilizer, BTB solution, and straws are used.

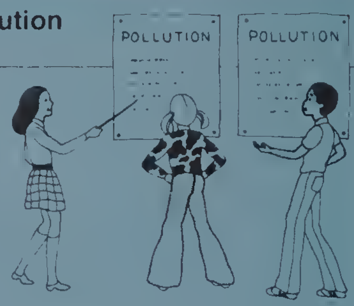


22. Your Community and Pollution. Children investigate their own communities to discover the kinds and sources of pollution. No special equipment is needed.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concept of pollution, turn to page 100 of the evaluation section at the back of the guide.

22 Your Community and Pollution



Ask your teacher or your parents about pollution where you live. Or, look at local newspapers or other sources of information.

Air Pollution

Is it mild, moderate, or severe?

Is it caused by cars, trucks, buses, or by factory smoke? Other?

What can be done to prevent it?

Water Pollution

Is there a polluted river, lake, or ocean nearby?

Is it caused by sewage, waste materials from factories, fertilizer runoff from farmlands? Other?

Soil Pollution

Do the farmers in your area have too much salt in the soil?

If so, what is it called?

Soil Pollution (continued)

Pesticides may pollute the soil, but they also kill insects that destroy crops. Is a certain amount of pesticide better than none at all?

Littering

Are there paper and trash in the streets?

Beer cans in the park?

Abandoned automobiles along the road?

What is your community doing to prevent littering?

SCIIS

Appendices

Evaluating Your Students

SCIIS bears upon many aspects of each child's growth and learning, and evaluation may therefore take a variety of forms. We believe the most significant evaluation should occur informally, while the regular classroom activities are going on and you can observe each child's attitudes, skills, and performance, rather than in formal "test" situations. Test scores alone are not appropriate to describe attitudes, and they often are inadequate measures of children's skills or understanding of science concepts. For these reasons we have provided three kinds of evaluation activities:

A. CONCEPT / PROCESS EVALUATION
- **Activity 1. A Classroom Ecosystem**
- **Activity 2. Evaporation and Condensation of Water**
- **Activity 3. Water Cycle**
- **Activity 4. Oxygen–Carbon Dioxide Cycle**
- **Activity 5. Cycles in an Ecosystem**
- **Activity 6. Pollution**

B. ATTITUDES IN SCIENCE

Curiosity	**Critical Thinking**
Inventiveness	**Persistence**

C. PERCEPTION OF THE CLASSROOM ENVIRONMENT
Our Science Class

An important feature of the evaluation materials is that they can help you identify problem areas and plan more effective teaching of subsequent parts of the unit. In concept/process evaluation, the "Follow-up" section at the end of each activity provides specific suggestions for remedying weaknesses in student understanding. The materials for assessing children's attitudes and their perception of the classroom environment contain suggestions that can help you improve your teaching effectiveness as well as the attitudes and performance of students. We hope you and your students find these activities both enjoyable and beneficial.

Concept / Process Evaluation

The activities in this section are designed to help you evaluate children's ability to identify and describe the major science concepts and processes of the unit. As explained in the unit "Overview" on page 1, these major concepts and processes are:

ecosystem	**water cycle**
pollution	**oxygen–carbon dioxide cycle**
	food-mineral cycle

In addition, certain secondary concepts and processes are introduced to help the children deal with their observations. These are: condensation, evaporation, precipitation, tundra, taiga, deciduous forest, desert, rain forest, grassland, and pollutant.

Objectives indicating the concepts and processes emphasized are listed at the beginning of each Part in the Teacher's Guide. Children's understanding and mastery of most concepts and processes can be evaluated informally as the class works through regular activities. It is worthwhile to evaluate children more than once during the unit, because individuals will achieve desired levels of competence at different times.

All of the concept/process evaluation activities can be carried out with individuals or small groups. Thus, you can use an activity to evaluate just the children for whom you are lacking notes or observations. Some activities also lend themselves to use with the whole class; this is indicated where appropriate.

The activities in this section provide you with ways to evaluate children's understanding of major concepts and processes presented in this unit. Some of the activities will also provide information about understanding of concepts and processes that are of secondary importance in this unit or that were introduced in earlier units.

Keeping records. One side of the Class Profile sheet (Evaluation Materials envelope, drawer 1) provides space to record results of each child's work in each activity. In evaluating children's progress we have found it most useful to distinguish three levels of understanding. These levels, and symbols convenient for recording them, are:

○ **Needs special assistance**
✓ **Check again**
● **Satisfactory**

The symbols have the advantage of being changed easily after a child gives evidence of progress. In addition to the symbol, you may add brief comments in the "Notes" column.

EVALUATION
ACTIVITY

1 A Classroom Ecosystem

SYNOPSIS

This activity measures the pupils' familiarity with the meanings of the terms food chain, community, and environmental factor as represented in a classroom aquarium-terrarium system.

Administer: ***to the entire class after Part One***

Suggested time: ***15 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Classroom Ecosystem answer page *

For the class:

Drawer 1

Classroom Ecosystem spirit master

* provided by the teacher

ADVANCE PREPARATION

Duplicate as many answer pages as necessary for your class.

EVALUATION SUGGESTIONS

Distribute the answer pages and tell the pupils that the picture represents the aquarium-terrarium systems they built in class. Explain that the items listed under the picture may not be exactly the same as those in their aquarium-terrarium systems. Read the instructions to the class and answer any questions concerning procedure.

Criteria. The correct answers to the questions are as follows:

1. The letter C should be written next to grass, pea plants, aphids, lady beetles, molds, bacteria, algae, guppies, hornwort, daphnias, and snails.
2. The letter *E* should be written next to soil, light, air, water, and heat.
3. The food chains that could be drawn are:

    peas → aphids → lady beetles

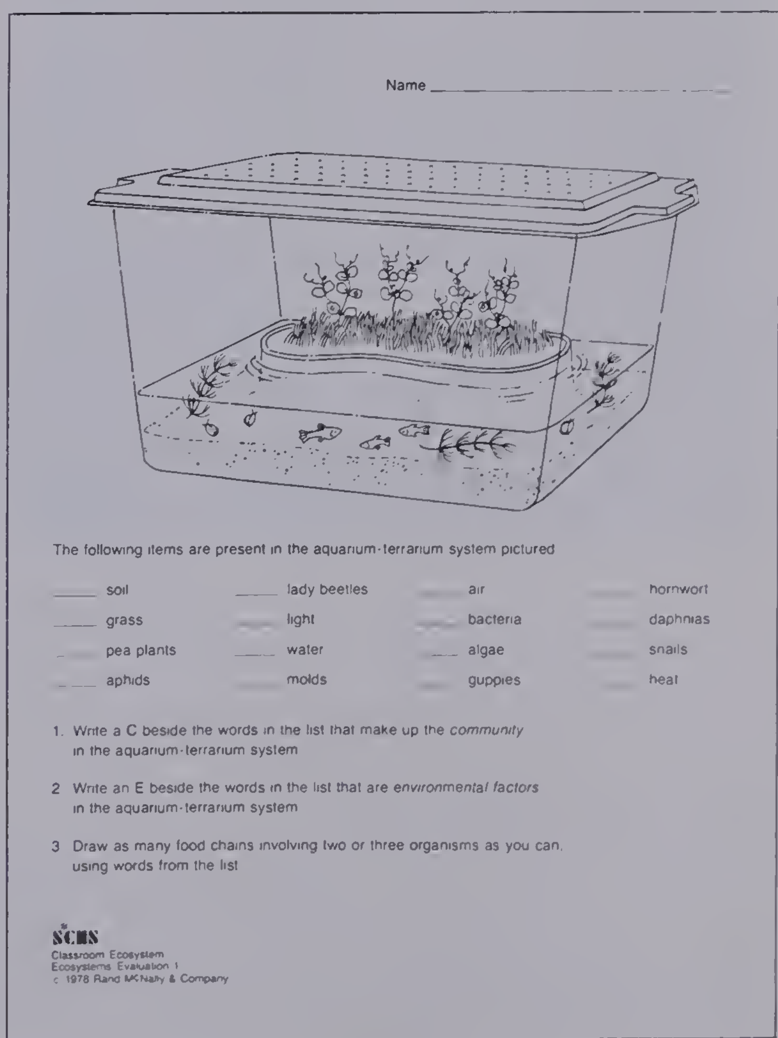
    algae → daphnias → guppies

    hornwort → snails

    (Some students may include molds and bacteria in their food chains by drawing an arrow from each plant and animal to molds and bacteria. Those who do this indicate a more complete understanding of food relations in a community than we expect.)

Children who drew arrows properly to depict at least one aquatic and one terrestrial food chain, identified only organisms as belonging in the community, and identified only physical factors as part of the environment have a good understanding of the concepts. Those who were able to diagram only one or part of one food chain and who did not properly separate all the organisms from the physical factors have a partial understanding. Those who were unable to diagram a food chain and who could not identify any of the appropriate words in items 2 and 3 need assistance. If you are keeping a record of your pupils' achievement on the evaluation profile, mark symbols for the three levels of performance or use your own recording technique.

Figure E-1. The Classroom Ecosystem spirit master.


Name ____________

The following items are present in the aquarium-terrarium system pictured

____ soil	____ lady beetles	____ air	____ hornwort
____ grass	____ light	____ bacteria	____ daphnias
____ pea plants	____ water	____ algae	____ snails
____ aphids	____ molds	____ guppies	____ heat

1. Write a C beside the words in the list that make up the *community* in the aquarium-terrarium system
2. Write an E beside the words in the list that are *environmental factors* in the aquarium-terrarium system
3. Draw as many food chains involving two or three organisms as you can, using words from the list

SCIIS
Classroom Ecosystem
Ecosystems Evaluation 1
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Follow-up. Review the Ecosystem chart with those children who demonstrated a lack of understanding on this evaluation activity. Ask the pupils to point out the food chains diagramed. Identify for them which parts of the chart represent the community and the environment.

EVALUATION
ACTIVITY

2 Evaporation and Condensation of Water

SYNOPSIS

This activity explores the students' understanding of evaporation and condensation.

Administer: ***to the entire class after Chapter 8***

Suggested time: ***5–10 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Water answer page*

For the class:

Drawer 1

Water spirit master

* provided by the teacher

ADVANCE PREPARATION

Duplicate the required number of answer pages.

EVALUATION SUGGESTIONS

Distribute the answer pages. Tell the pupils that the picture illustrates an experiment where two cups containing water were placed under a lamp. Cup *A* has no lid but cup *B* did. Read the questions to the class and let the children proceed.

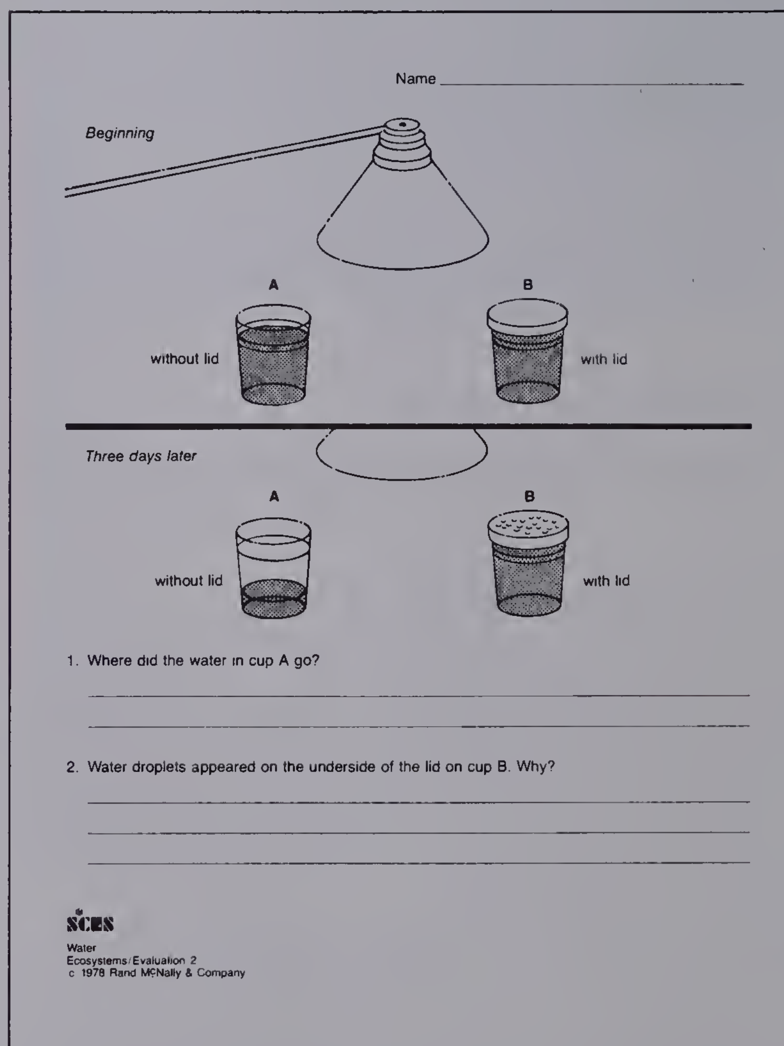
Criteria.

1. Acceptable answers are that the water in cup *A* evaporated, that it changed to water vapor, or that it went into the air.
2. Answers should state that the water evaporated, then condensed and formed droplets on the underside of the lid. Some students might have added that the lid had a lower temperature than the air inside the cup, and as a result the water vapor condensed.

Children who answered both questions correctly have a good understanding. Those who correctly answered one question have a partial understanding, while those who answered neither correctly need help.

Follow-up. Check the work on student manual pages 11 and 12 of pupils who failed to answer the questions correctly. Question the children about the relation of their answers in the student manual to the question on the answer page. If the manual pages have not been correctly filled in, ask the students to repeat the experiment in Chapter 7.

Figure E-2. The Water spirit master.



EVALUATION ACTIVITY

3 Water Cycle

SYNOPSIS

This activity is designed to measure the pupils' understanding of the water cycle.

Administer: ***to the entire class after Part Two***

Suggested time: ***10–15 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Water Cycle answer page*

For the class:

Drawer 1

Water Cycle spirit master

* provided by the teacher

ADVANCE PREPARATION

Duplicate the necessary number of answer pages.

EVALUATION SUGGESTIONS

Distribute the answer pages to the children. Read the items to the class and ask the students to proceed with the activity. Walk among them while they are working to answer procedural questions.

Criteria. Acceptable answers to the questions are as follows:

1. Rain and snow fall from clouds.
2. Ocean water evaporates and forms clouds; the clouds are blown over land by winds; there, water in the clouds condenses and falls as rain and snow on the mountains where the river is formed.
3. The rivers and streams would dry up.

Pupils who answered only question 1 correctly have a partial understanding of the natural water cycle. Those who correctly answered questions 1 and 2 but not 3 understand more. Only those students who correctly answered all three questions have a satisfactory understanding.

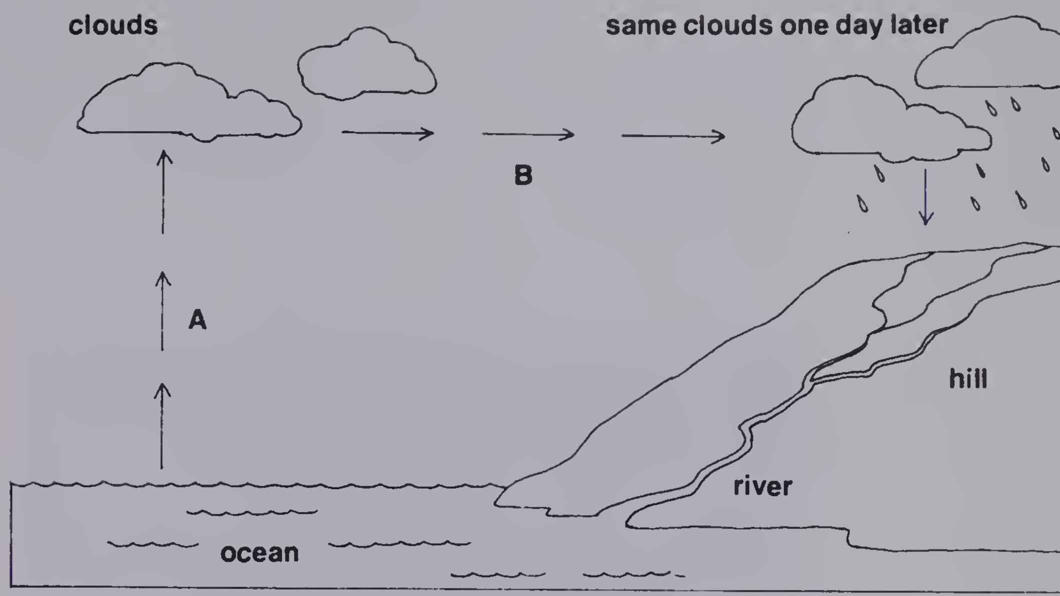


Figure E-4. Use this drawing in giving children further help.

Follow-up. Gather the children who did not answer the questions correctly. Draw a picture like Figure E-4 on the chalkboard and discuss it. You might ask:

1. What is shown by arrow *A*? (evaporation)
2. What is shown by arrow *C*? (condensation)
3. What is represented by arrow *B*? (movement by wind)

Continue the discussion by asking other questions relating air movement (wind) to the water cycle.

Figure E-3. The Water Cycle spirit master.

Name ______________

1. Streams do not flow uphill. How does water get to the tops of mountains where streams begin?

____

2. Water from a river finally reaches the ocean, which is far from the source of the river. How does the water get back to the source of the river?

____

3. What do you think might happen to rivers and streams if the wind stopped blowing and the air did not move from place to place over the surface of the earth?

____

SCIIS
Water Cycle
Ecosystems Evaluation 3

EVALUATION
ACTIVITIES

4 Oxygen–Carbon Dioxide Cycle

SYNOPSIS

In this activity, you examine the students' understanding of the gases produced by plants and animals in light and in dark.

Administer: *to the entire class after Part Three*

Suggested time: *10–15 minutes*

EVALUATION MATERIALS

For each child:

1 copy of BTB Experiments answer page*

For the class:

BTB Experiments spirit master

* provided by the teacher

ADVANCE PREPARATION

Duplicate the number of answer pages your class will need.

EVALUATION SUGGESTIONS

Distribute the answer pages and read the text aloud as the students follow along on their papers. Make sure they understand that experiment 1 was done in the light and experiment 2 in the dark. Walk among the children while they are working to provide help with spelling and writing.

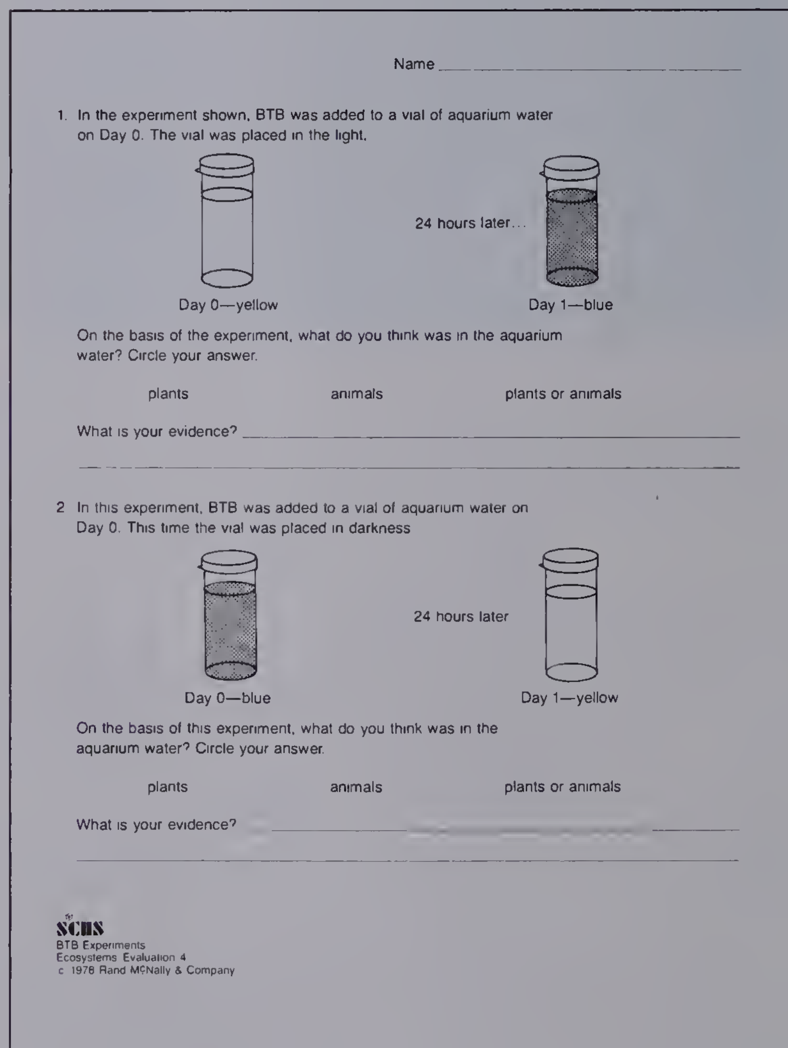
Criteria. Answers to the questions are as follows:

1. Plants. The evidence is that plants in the light photosynthesize, removing carbon dioxide from the water.
2. Any item may be circled if it is accompanied by acceptable evidence:
   plants—plants in the dark produce carbon dioxide;
   animals—animals produce carbon dioxide;
   plants or animals—both plants and animals give off carbon dioxide.

Pupils show good understanding of the oxygen–carbon dioxide cycle if they answered all questions correctly. Those who answered one or two questions correctly show partial understanding, and those who were unable to answer any questions need assistance.

Follow-up. Talk with the pupils who gave incorrect answers or explanations. Review with them the results of their experiments with BTB and plants and animals in the light and in the dark. Emphasize the evidence for the statement that blue BTB turns yellow when carbon dioxide is added, and that yellow BTB turns blue when carbon dioxide is removed. Many children are confused on this latter point, thinking that yellow BTB becomes blue because of the presence of oxygen. If any students are still uncertain after the discussion, have them repeat whatever BTB experiments you think would help to clarify their misunderstanding.

Figure E-5. The BTB Experiments spirit master.


Name ____________

1. In the experiment shown, BTB was added to a vial of aquarium water on Day 0. The vial was placed in the light.

On the basis of the experiment, what do you think was in the aquarium water? Circle your answer.

plants   animals   plants or animals

What is your evidence? ____________

2. In this experiment, BTB was added to a vial of aquarium water on Day 0. This time the vial was placed in darkness.

On the basis of this experiment, what do you think was in the aquarium water? Circle your answer.

plants   animals   plants or animals

What is your evidence? ____________

SCIIS
BTB Experiments
Ecosystems Evaluation 4

EVALUATION
ACTIVITY

5 Cycles in an Ecosystem

SYNOPSIS

Students demonstrate their understanding of the interactions (cycles) within an ecosystem.

Administer: ***to the entire class after Part Four***

Suggested time: ***5–10 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Cycles in an Ecosystem page*

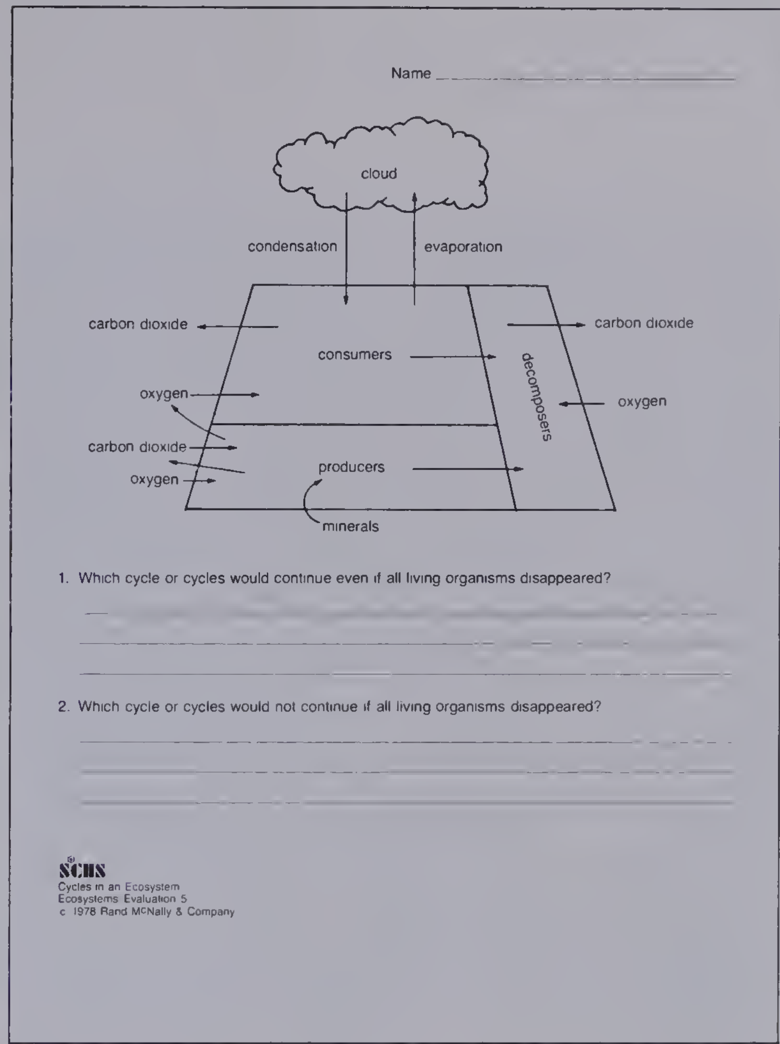
For the class:

Drawer 1

Cycles in an Ecosystem spirit master

* provided by the teacher

Figure E-6. The Cycles in an Ecosystem spirit master.


Name ____________________

1. Which cycle or cycles would continue even if all living organisms disappeared?

2. Which cycle or cycles would not continue if all living organisms disappeared?

SCIIS
Cycles in an Ecosystem
Ecosystems Evaluation 5
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ADVANCE PREPARATION

Duplicate an answer page for each child.

EVALUATION SUGGESTIONS

Distribute the answer pages. Tell the pupils that the picture illustrates the water cycle, the oxygen–carbon dioxide cycle, and the food-mineral cycle in an ecosystem. Read the questions to the class and let the children proceed.

Criteria. Answers to the questions are:

1. The water cycle.
2. The oxygen–carbon dioxide cycle and the food-mineral cycle.

Children who answered both questions correctly have a good understanding. Those who answered one question have a partial understanding, while those who answered neither correctly need help.

Follow-up. Using the diagram of the "Cycles in an Ecosystem" on the answer page, question the pupils who failed to answer the questions correctly. Point to the terms Producers, Consumers, and Decomposers, and ask the pupils what they refer to. Also point to the various arrows and ask what they represent.

EVALUATION ACTIVITY

6 Pollution

SYNOPSIS

You examine the children's understanding that pollution may result from a change in concentration of a normal part of an ecosystem and that what pollutes the environment for some organisms may benefit others.

Administer to: *the entire class after Part Five*

Suggested time: *5–10 minutes*

EVALUATION MATERIALS

For each child:

1 copy of Pollution answer page*

For the class:

Drawer 1

Pollution spirit master

* provided by the teacher

ADVANCE PREPARATION

Duplicate the number of answer pages required for your class.

EVALUATION SUGGESTIONS

Distribute the answer pages. As the children examine the page, read the directions and questions and clear up any misunderstandings.

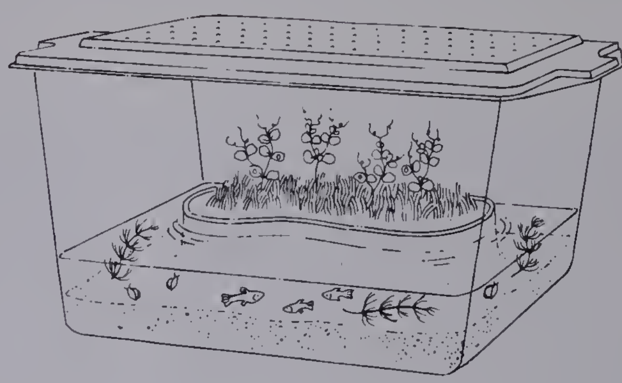
Criteria. Answers to the questions are:

1. Fertilizer or carbon dioxide.
2 and 3. Pupils who circled fertilizer or carbon dioxide and stated that animals would be harmed, while plants might benefit, demonstrate a satisfactory understanding. Students who selected the correct factors but could not explain their selections have a partial understanding, while those who were unable to respond need help.

Follow-up. Review the experiments recorded on pages 31 and 32 of the student manual with pupils who demonstrated a lack of understanding.

Figure E-7. The Pollution spirit master.

Name ____________________



The following environmental factors are normal and necessary parts of the aquarium-terrarium system pictured.

water	fertilizer	carbon dioxide
light	heat	oxygen

1 Any of the factors could become a pollutant if added to the system in a quantity large enough to harm organisms Circle one factor in the list that could harm some organisms while benefiting others

2. What organisms might be harmed? ____________________

3 What organisms might be helped? ____________________

SCIIS
Pollution
Ecosystems Evaluation 6

Attitudes in Science

These comments are designed to help you assess four major attitude areas that can indicate developing scientific literacy in children.

When using this phase of evaluation, keep in mind the question "In what ways is the child behaving like a scientifically literate individual?" During your day-to-day science teaching, look for evidence of positive attitudes in the following areas:

Curiosity. Children who pay particular attention to an object or event and spontaneously wish to learn more about it are being curious. They may give evidence of curiosity by—

- using several senses to observe organisms and other objects
- asking questions about objects and events
- eagerly examining organisms, equipment, or other materials at the time they are first distributed
- showing interest in the outcomes of experiments

Inventiveness. Children who generate new ideas are being inventive. These children exhibit original thinking in the interpretation phase of an activity. They may give evidence of inventiveness through actions or verbal statements by—

- using equipment in unusual and constructive ways
- suggesting new experiments
- describing novel conclusions from their observations

Critical thinking. Children who base suggestions and conclusions on evidence are thinking critically. They may exhibit critical thinking largely through verbal statements by—

- using evidence to justify their conclusions
- pointing out contradictions in statements by others
- changing their ideas in response to evidence

Persistence. Children who maintain an active interest in a problem or event for an extended period of time are being persistent. They are not easily distracted from the subject at hand. They may give evidence of persistence by—

- continuing to investigate materials after the novelty has worn off
- completing an activity even though their classmates have finished earlier
- redoing an experiment while making some manipulative or procedural changes to improve the results

Of course, the behaviors related to these areas are not restricted to science; they may be observed in other curriculum areas when suitable opportunities exist.

Observing a whole class busily engaged in diverse activities makes attitude-evaluation of individuals virtually impossible for one teacher. We recommend that you focus your attention on attitudes demonstrated by four or five children during each session. You may do this by following an alphabetical class list or by concentrating on one or two teams per session. If you learn something about four or five children during any one session, then you will be able to make a note about each child four or five times in the teaching of one SCIIS unit. Active, vocal children will gain your attention more frequently; quiet children may escape your notice for some time. Adopting a plan for observing class members ensures that you will not overlook any individuals.

In addition to observing the children, an effective way to measure attitudes is to ask divergent questions about the work they are doing. By listening carefully to their responses, you will obtain significant feedback regarding their attitudes.

Keeping records. Space is provided on the Class Profile sheet (Evaluation Materials envelope, drawer 1) for recording observations about each student's attitudes four times during the unit. In the "Notes" column, you may include a short statement indicating what you observed each time the child was selected. Many teachers make their notes while the children are cleaning up at the end of the activity.

The use of this informal but organized assessment system will provide you with a great deal of information about the children's development and will assist you in planning for effective instruction in science.

Perception of the Classroom Environment

This activity indicates how the children assess the nature of the classroom during science — or how they would like it to be. The activity answers the following questions:

• What do the children think about major topics studied in this Part of the unit?

• Do the children see science class time being used in the way you intend it to be used? Do they feel that they are active participants?

• Which kinds of science activity — experimenting, writing or drawing, listening to the teacher, discussing, or reading—do they generally prefer?

Children are sensitive to suggestions from adults. To avoid unduly influencing pupils' perceptions of the classroom, you must be completely noncommittal about what you think is most important or most interesting.

In our experience, most children prefer experimenting, but some do prefer to read or listen to the teacher. Certainly all five kinds of activity are important in a balanced science program, and they should be combined in a way that benefits children most. In field tests of these materials, teachers reported that they could anticipate many children's responses, but that there were usually a few whose perceptions or preferences surprised them and helped them to adjust their teaching accordingly.

The following activity has been written in a style similar to that of the regular SCIIS activities in the hope that the children will see it as a natural part of the learning sequence rather than as a formal examination. The activity may be used at the end of each Part in the unit.

Science Class Report

SYNOPSIS

Children use a report form to indicate (1) their opinions about topics investigated in the Part just completed; (2) how they think their science class time was used; and (3) which kinds of science activity they liked best.

Administer: *to entire class at conclusion of each Part*
Suggested time: *five to ten minutes*

EVALUATION MATERIALS

For each child:

1 Science Class report page*

For the class:

Drawer 1

Science Class report form
spirit master (Evaluation Materials envelope)

* provided by the teacher

ADVANCE PREPARATION

Duplicate the required number of the Science Class Report pages. (If you are using this activity for the first time, you will probably want to make enough copies to use the activity at the end of each Part in this unit.)

For question 1, list on the chalkboard the major topics or activities investigated in the Part just completed.

Your list could include some of the following:

Part	TOPIC
1	making terrariums
2	water cycle
3	breathing into BTB
4	identifying ecosystems
5	fertilizer and pollution

EVALUTION SUGGESTIONS

Distribute copies of the Science Class Report page. The first time you use this activity, explain the procedure to the class. For question 1, have the children copy your list of major topics from the chalkboard. Ask them to rate the topics by writing their opinions on the lines

provided — either in words (interesting, boring, difficult, easy, seemed long, seemed short, etc.) or by means of letter grades. For question 2, ask the children to circle the word that best describes the amount of time they think was spent on each kind of activity during the Part. For question 3, ask them to circle one or two of the words or phrases in question 2 that describe the kinds of activity they prefer.

Collect the papers and review the responses. Look for topics that aroused a great deal of interest, and follow these up with additional optional activities from the appropriate chapters. Look for "weak" spots — topics or activities that were not well liked by a large number of pupils. Try to identify the reasons for such negative opinions. Discuss these reasons with the class, and invite the children to suggest ways of modifying the treatment of the topic that would make it more interesting.

As you review responses to questions 2 and 3, keep in mind that a balanced program includes all the kinds of activities listed; but in an investigative program such as SCIIS, experimenting usually should be most prominent, and reading and listening to the teacher usually least prominent. If the children perceived a different emphasis than you intended, review "Helping Children Learn with SCIIS" (page xvi) and the "Teaching Suggestions" in the next few chapters, to help you plan future science periods.

NAME ____________

Unit ____________ Part ______

Science Class Report

1. What did you think of these?

TOPIC	OPINION

2 In science class, how much time did you spend doing each of these?

ACTIVITY	TIME SPENT			
Experimenting	much	some	a little	none
Writing or drawing	much	some	a little	none
Listening to the teacher	much	some	a little	none
Discussing	much	some	a little	none
Reading	much	some	a little	none

3 In the list above, circle the one or two kinds of activity you like best.

SCIIS

Glossary

The definitions in this glossary are intended for your use and quick reference. We do not recommend that you use them verbatim to answer children's questions.

animal-eater – an animal that uses other animals as a food source.

bacteria – a group of microscopic organisms; some are decomposers that break down (decay) feces and dead organisms. Bacterial action can often be recognized by a foul odor.

bromothymol blue (BTB) – a dye that is an acid-alkaline indicator. Its color depends on the acidity of the solution in which it is dissolved. It is yellow in acid solution (vinegar, lemonade), deep blue in alkaline solution (baking soda, household ammonia, limewater), light blue in pure water, and yellow-green in weakly acid solutions (mixed baking soda and vinegar, breath bubbled through water). In some localities, tap water is slightly acid and produces a blue-green BTB solution; a drop of limewater or household ammonia solution will turn the BTB solution back to blue.

carbon dioxide – a colorless, odorless gas contained in the atmosphere and given off by both plants and animals.

community – populations of plants and animals that live in the same area and are dependent on one another for food and other requirements.

condensation – the conversion of a material from the gaseous to liquid state.

consumers – the group of animals in a community that eats plants or other animals. The consumers make up one functional group in the community. The other functional groups are producers and decomposers.

decay – the breakdown of organic matter due to the digestive action of microorganisms such as molds and bacteria.

deciduous forest – the ecosystem of the eastern United States that consists mainly of deciduous trees.

decomposers – the group of organisms in a community (usually bacteria and molds) that causes decomposition (decay) of organic matter, releasing raw materials to the environment.

desert – the ecosystem of the southwestern United States that is characterized by an arid climate and plants adapted to dry conditions.

ecosystem – a unit consisting of a community interacting with its physical environment.

environment – the combination of all external factors that affect and influence the growth, development, and reproduction of organisms.

environmental factor – any part of the environment, such as chemicals, water, or light, that affects organisms and to which they respond.

evaporation – the conversion of a material from the liquid to gaseous state.

food – that combination of raw materials which is used by plants and animals for nourishment. Plants make food by the process of photosynthesis.

food chain – a diagram depicting the food relationships among plants, plant-eaters, and animal-eaters. For example:

wheat → crickets → frogs → raccoons;
corn → man.

food-mineral cycle – the transfer of minerals from the soil to producers (where they are incorporated in the food manufactured by plants), to consumers, to decomposers, and then to the soil where they are available again for use by plants.

grassland – the prairie and plains ecosystem of the central United States.

humidity – moisture or dampness in the air.

minerals – naturally occurring inorganic substances. Some minerals are released to the soil by decomposers and are used by plants.

molds – decomposers characterized by a fuzzy appearance. Molds may be different colors.

optimum – that part of a range of an environmental factor in which an organism lives best. (See *range*.)

organic matter – animal wastes and dead organisms.

organism – an individual living thing; any plant or animal.

oxygen – a colorless, odorless gas contained in the atmosphere. It is produced by photosynthesis and is used by both plants and animals to support life.

oxygen–carbon dioxide cycle – the exchange of gases between organisms and their environment.

photosynthesis – the process by which green plants manufacture food from certain raw materials with light as the source of energy.

plant-eater – an animal that uses plants as a food source.

pollutant – any substance that is added to an ecosystem in a quantity harmful to organisms.

pollution – addition of a pollutant to an ecosystem.

population – a group of organisms of the same kind living and reproducing in a particular area.

precipitation – rain, snow, or other forms of condensation in the natural water cycle.

producers – the green plants in a community. They produce the food that supports all the organisms living in the community.

range – all the intensities of an environmental factor between a minimum and a maximum. A range in the amount of water may be from dry to soaked. (See *optimum*.)

scrub forest – an ecosystem that, in the United States, is found only in California. Conditions are fairly dry, and the vegetation consists mainly of low trees.

taiga – the moist, coniferous forest ecosystem of the northern United States and Canada.

tropical rain forest – the humid, warm ecosystem characteristic of Florida and Hawaii.

tundra – the treeless-plain ecosystem, having a permafrost layer beneath the soil surface, found north of the taiga.

water cycle – the exchange of water between earth and its atmosphere as a result of evaporation and condensation.

SCIIS Plants and Animals

The organisms used in the SCIIS life science units have been chosen for their resiliency and ease of maintenance as well as their behavior, feeding relationships, and life cycles; no complicated feeding or housing arrangements are required. Nevertheless, some preparations for the arrival of organisms are necessary. Aquatic organisms, for instance, need aged tap water, in which the chlorine content is reduced below the level that is harmful to the organisms. Terrestrial organisms need a container with plants or animals that serve as food. On the following pages you are given both background and maintenance information on the plants and animals studied in this unit, as well as general information on planning and ordering procedures.

PLANNING THE UNIT SCHEDULE

Living organisms are the focus of the children's investigations in the SCIIS life science units. Ordering and maintaining the organisms during the teaching program are therefore important responsibilities for you and your pupils.

In planning to teach a life science unit, first examine the "Schedule of Activities" on the last page of this guide. The schedule identifies the activities in the unit and indicates the approximate time required for each one. Also indicated are the times when organisms should be ordered. Use the schedule along with the following instructions to make sure that you receive living organisms when you need them.

ORDERING LIVE ORGANISMS

The seeds and live organisms for SCIIS are to be obtained through Rand McNally & Co. In each kit you will find an envelope containing one or more forms to be used in ordering the organism shipments.

What to order. The contents of the *Ecosystems* shipments are as follows—

EC-1: Daphnias, hornwort, pond snails, algae.
EC-2: Daphnias, pea aphids, lady beetles, guppies.

When to order. As you proceed through the Teacher's Guide, watch the "Getting Ready" notices—you will be reminded to send in each order form well in advance of the time when you will need this shipment. It is very important to you and the children that the organisms arrive on time: *You must make sure that the order is mailed three weeks before the shipment is needed.* This is because the supplier not only must process the order, package the shipment, and allow time for shipping, but in some cases must hand-sort the animals. The organisms must be carefully selected so that they will be the correct age and size and in proper condition for use in the classroom.

How to order. Complete the order form for the shipment, including the date when needed, your name, and the school's exact address. Do *not* have these shipments sent to your district's central supply department or warehouse! The arriving organisms will need your care immediately and must not sit on a shelf. To prevent your shipment from being treated casually when it arrives at your school, forewarn the mail or package sorter of its impending arrival and firmly request that you be notified as soon as it is received. Too many organisms have died in their shipping containers after languishing for a week under a counter only a few doors away from the waiting children.

Preparing for arrival. The preparations necessary for SCIIS organisms are minimal, but they are important. The sooner you get the organisms out of their shipping containers and into their proper habitats, the better for the organisms.

Before any organisms arrive, tell the children that in handling the plants and animals, they should be as careful as they would be with their own pets. No SCIIS organisms will hurt them, but the children should keep their hands away from their faces while working with the organisms and wash their hands afterward.

Water. Water to be used in aquariums can usually be taken from the tap, but you should not put organisms into tap water immediately. "Age" it by leaving it uncovered for at least two days to allow the chlorine to escape. If you age water in 1-gallon jugs with small necks, be careful not to fill the jugs completely, or the water's top surface area will be too small for rapid exchange of gases.

Another source of water is spring water from a grocery store or a bottled water company. Do not confuse spring water with distilled water—they are different! We do not advise using distilled water, because it is not supposed to contain any chemicals other than pure water. All animals need certain elements that are always present in spring, pond, or tap water.

Sand and soil. These items are provided with the equipment kit and have been carefully chosen for suitability with the organisms and equipment in the program. Sand to be used in an aquarium must be rinsed of dust so the aquarium water will remain clear: half-fill an aquarium with sand; add water while stirring the sand; and pour off the cloudy water. Repeat these steps until the water remains clear after the sand has settled. If you wish, let that water remain in the aquarium for two days; you will then have an aquarium containing both rinsed sand and aged tap water.

The soil has been premixed in the proper proportions for good growth and drainage, and it needs no further preparation.

Plants. In some units, arriving terrarium animals (such as the aphids in *Ecosystems*) should have growing plants waiting for them. Be sure to plant seeds at least a week before you expect the shipment in such cases.

PLANTING SEEDS

The seeds are shipped with the kit and are available for your use as soon as you wish to begin the unit. You are probably familiar with the kinds of seeds used in SCIIS.

No seeds in the program contain toxic materials or have any associated with them. Because children may put seeds in their mouths, you should avoid using seeds sold for garden use—these may have been treated with toxic chemicals that retard mold growth. The SCIIS seeds have been selected for high viability: nearly all of them will germinate, provided that they are planted and watered properly.

The only common classroom problem children have with seeds is that the seeds do not germinate. This is often caused by excessive watering. Not watering will of course also result in no germination, but that problem is unlikely in a classroom.

CARE OF PLANTS IN THE CLASSROOM

A classroom isn't always the best environment for plants. Your room may be very dry, cold, hot, bright or any combination of factors. But, by concentrating on the three environmental factors over which you can have some control—water, light, and temperature—you will have success with the plants we have selected.

Before beginning the unit, decide where you will grow the plants, keeping in mind the amount of light, temperature, and drafts. Also consider whether the plants will be bumped into often, and if the children will be able to observe them easily. Using the following list will help you to find the best place for your plants and to give them good care.

Water.

- The amount of water is the *most* important environmental factor for plant development and growth. While classroom temperature and light variations can speed up or slow development and growth, excessive water variations quickly *kill* plants. A fast- or slow-developing plant is infinitely better than a dead one!
- Use enough water to darken the soil.
- The soil is too wet if (1) you can squeeze water from a large pinch of soil, (2) you can see water in the planter base, or (3) a seed rots.
- The soil may be too dry if (1) a pinch of soil crumbles, (2) the seeds in it don't sprout, or (3) the seeds in it sprout later than seeds that were planted in moister soil.
- We can give no prescription for how much water should be given, or how often. Each classroom is different, and you must watch your plants' soil.
- The heat and low humidity in some classrooms cause plants and soil to dry out very rapidly. In such rooms avoid placing the plants in any drafts.
- For vacation periods place all the plants together, water liberally, cover with a large plastic sheet (a drop cloth or dry cleaners' bag), and leave the light source on (outside the plastic sheet) to help maintain the temperature above 10°C (50°F). Tell the custodian to leave the light on.

Light.

- Light is not needed until plant parts emerge from the soil.
- After emergence, the equivalent of a 100-watt bulb about 80 cm from the plant is sufficient for good growth.
- To estimate the proper height of the light source above the plants, hold your hand next to the plants. If the light shining on the back of your hand feels uncomfortably warm, raise the bulb. If your hand feels cool, lower the bulb.
- The light source supplied in the kit is adjustable. Use this feature for altering both the light intensity and the temperature.
- Whether the light is from sunlight or from the light source in the kit, the plants in this unit will grow. Natural light is better than artificial unless you have so much sunlight that the soil and plants dry out or become too warm. A table near the windows, but not in the draft of the heater or air conditioning fan, is a fine place for storing plants.
- Windowsills are often problem spots. Depending on the time of year, they may be too hot, too cold, or too windy; or the shades and curtains may knock over the plants.

Temperature.

- 15 to 35°C (59–95°F) is the acceptable range. However, 20–25°C (68–77°F) is best.
- If you use the light source provided in the kit, remember that whenever the plant is receiving light it is also absorbing heat from the bulb, and the plant may be much hotter than the room. Adjust the lamp height as necessary.

The heat from any source of light may cause the soil to dry out, which is critical. Water is more important to plants than either light or heat.

Possible plant problems. In spite of your conscientious care, you may have trouble with seeds or plants. If you do, use this checklist to analyze the problem.

A CHECKLIST OF PLANT PROBLEMS

Failure of seeds to develop.

__ Too much water causes rot. Dig up one seed. If it is rotten discard the seeds, let the soil dry out, and start over.

__ If too little water has been added, the seeds will be unchanged from when they were planted. Water the soil thoroughly after replacing the seeds, and be sure they are not receiving too much heat.

__ You may not have waited long enough. Some seeds are slower to develop than others, though the kinds of seeds provided in the kits should sprout within nine days. Seeds will develop slowly if they are cold or haven't received enough water.

__ The seeds may have been planted too deeply, or the soil may have been pounded down on top of them. If you think this is the problem, dig the seeds up and plant them again.

__ In any group of seeds, a few will fail to develop. Assume 9 out of 10 seeds planted will develop, and be sure the children plant enough seeds to allow for this.

Animals on the plants or soil.

__ This usually occurs in overwatered plants. Reduce the amount of water given, and be sure none is standing in the planter bases.

__ Animals are free sources of live organisms — use them. They probably will show different life cycle forms. Aphids and gnats are common and will reproduce on plants and soil.

Blemishes.

__ Symptoms such as discolorations, leaf curl, and fuzzy spots on soil or plants are probably caused by molds or other fungi. Dry the plants out by watering them less and increasing the amounts of light and heat they receive.

__ Blemished plants will not necessarily die. To prevent infection of healthy plants, isolate the infected plants until they recover.

Breakage.

__ Protect plants from breaking by storing them where the children are not likely to knock them over or brush against them.

__ Allow only a few children to retrieve their plants at a time. This reduces jostling that might otherwise occur.

__ Encourage children to be gentle with the plants as they work with them.

__ Avoid storing plants near windy doorways or windows, where they might be blown over.

__ Use support sticks and ties for tall plants grown in pots.

Miscellaneous problems.

__ Sick-looking or dead plants may have lost too much water over the weekend. The solution is to water plants more on Fridays, or to cover them with waterproof plastic wrap, being careful the plastic does not break them.

__ Diseases are possible, but unlikely. Discard any diseased plants and plant new seeds.

__ Weak stems are usually caused by an overabundance of water, by the addition of more soil after the plant has sprouted, or by insufficient light. Have the children use less water, support the plants with sticks and ties, and be especially careful with these plants.

__ Kinked stems can be salvaged if they are kept straight with splints. Use yarn, tape, or a twistem to attach a stick or pencil to the weakened section of the stem.

CARE OF ANIMALS IN THE CLASSROOM

All the animals selected for use in this program will live in your classroom. However, we often find variations among classrooms that can cause some problems. Your room may be too dry, cold, bright, or hot for some of the animals. In many schools, the heat is turned down at night and on weekends; some schools are dark; in others the blinds must be pulled down every afternoon; and some are in areas of very low or high humidity. Some rooms with a southern exposure heat up. Rooms with windows on the west side may have bright sunlight at four or five o'clock, after everyone has gone home—everyone but the SCIIS organisms, which are then literally in hot water. The next morning the water has cooled and everything looks normal, but many organisms are dead.

To prevent such disasters and the resulting disappointments for the children, set aside ten minutes to read the "Plant and Animal Shipments for *Ecosystems*" section, describing the key points in maintaining each of the animals.

Environmental factors which can most severely affect classroom animals are water, light, temperature, and food.

Water. As all the animals in this unit are aquatic, all you have to do is keep enough aged tap water in the aquariums.

Light and temperature.

- The presence or absence of light alone will not harm your animals. However, the light source also gives off heat that builds up inside animal containers.
- Check the temperature with the back of your hand, as described on page 87.
- For each animal, there is an optimum temperature, but none of the animals supplied will be harmed if you keep the temperature between 10°C (50°F) and 25°C (80°F).
- Temperatures below 23°C (75°F) will tend to slow the rate of development a little. But as with plants, an organism that develops too slowly is far better for your purposes than a dead one.
- When in doubt about whether to raise the temperature another degree or two, ask yourself whether there is danger of raising it too much if you forget to monitor the increase. If so, do not try to raise the temperature. Remember, this unit *cannot* be taught without live organisms.

Food.

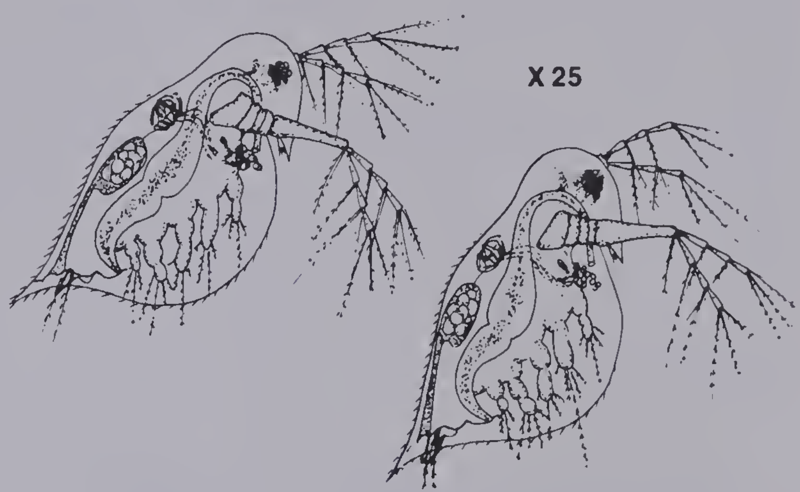
- Daphnias eat algae, and snails feed on plants and detritus in the aquarium. You do not need to provide food for them under ordinary conditions.
- The pea aphids are the lady beetles' food supply.
- Guppies eat daphnias or fish food.

PLANT AND ANIMAL SHIPMENTS FOR *ECOSYSTEMS*

Daphnias.

Receiving the organisms. When you receive the daphnias ('daf-nē-əz), pour the contents of the shipping container into a dip net, discarding the liquid. Then turn the dip net inside out, submerge it in a culture of algae you have prepared, and wash the daphnias from the net.

Figure L-1. Daphnias.



Classroom care and maintenance. Though daphnias do not require light, algae do. Therefore, light that produces good algal growth will also benefit the daphnia population.

Place the culture of algae and daphnias near enough to the light source that the light shines onto the water, but not too near: the culture can easily become too hot. The optimum temperature range is 20–25°C (65–80°F). (You can estimate the temperature at any given point under the light source by placing your hand there. If the light shining on the back of your hand feels uncomfortably warm, the temperature there is too high for other organisms as well. Similarly, if your hand feels cold, that place is probably too far from the light.) Adjust the height of the light bulb or move the aquarium to the side if the water gets too hot. Above or below their temperature range, the animals will die, or they will produce special black egg cases rather than live young.

If you wish to maintain a culture for several months, transfer some daphnias to a fresh container of algae water every two or three weeks.

Description and natural history. Daphnias *(Daphnia),* also called water fleas, are small aquatic animals related to lobsters, crayfish, and crabs. The animals can often be found in freshwater ponds, lakes, or slow-moving streams, where they feed on algae and decaying organic material.

The shell (carapace) and some of the organs are transparent. The vibrating legs, the single black eye, and the intestine (usually filled with green algae) show

through the carapace. These parts, as well as the two large antennae which are used for swimming and which are not enclosed by the carapace, can be seen with a magnifier.

When fully grown, a daphnia is about 3 mm long. It grows in distinct stages rather than showing gradual and uninterrupted increase in size. Its rigid carapace is cast off periodically and, as the animal grows, a new and larger carapace forms and hardens.

Most daphnias are female and can reproduce without fertilization. Ten to twenty eggs appear in the brood pouch every few days. These eggs quickly develop into tiny daphnias inside the pouch, and the young are released live. The young grow rapidly and soon produce eggs of their own.

Disposal. After the unit is completed, any remaining daphnias can be used as an excellent fish food.

Hornwort.

The pond snails and hornwort *(Ceratophyllum)* in Shipment EC-1 are in the same plastic bag.

Figure L-2. Hornwort.

X ¼

Receiving the organisms. The plastic bag should be opened immediately and the organisms dropped into aged tap water. (Rinse the hornwort first.)

Classroom care and maintenance. Like algae, these aquatic plants require moderate light and a 15–25°C (60–80°F) temperature.

Description and natural history. Hornwort has bushy stem tips, which account for the plant's other common name of coon tail. Leaves are arranged in spiral fashion around the stem. When flowers and fruits form, they are seen as small red cylinders. Muskrats and birds feed on these plants.

Disposal. To dispose of excess plants, wrap them in a towel and discard.

Pond snails.

Receiving the organisms. Be sure, when receiving a shipment of snails, to place them only in a container of *aged* tap water. Though their shells may make them appear hardy, snails are sensitive to acidity and small amounts of certain compounds that are present in tap water.

Figure L-3. A pond snail.

X 4

Classroom care and maintenance. For normal classroom use, no special foods are necessary for the snails; they feed on algae and decaying material.

Description and natural history. Snails are frequently found climbing on plants, rocks, and other submerged objects; small ones can even be seen hanging suspended from the surface film of water. Snails are eaten by fish, ducks, and large insects.

The large soft part of the snail which protrudes from the coiled shell is called the foot. It consists mainly of muscle tissue and is the organ of locomotion. Usually snails move by creeping over a thin film of mucus deposited by the foot.

The head is located at the front of the foot and has two tentacles. On each tentacle is an eye. The mouth is on the lower surface of the head. Within the mouth there is a rasplike tongue which scrapes across the food material and reduces it in size for swallowing.

Most snails eat the soft tissues of plants, but some are scavengers that eat dead plants and animals. They will remove algae and detritus from the aquarium walls, making the contents more visible.

Snails lay eggs in gelatinous clumps on leaves, on sticks, or on other objects. Frequently you will find snail eggs on aquarium walls. Tiny snails, looking very much like the adults, crawl out of the jellylike mass after one or two weeks.

Disposal. When you have finished with them, pond snails will make a good addition to aquariums in other classrooms. If they must be killed, put them in a plastic bag and freeze them.

Algae.

Receiving the organisms. When the shipment arrives, shake or swirl the container, then look at the liquid to see if it is green. If it is not, call the telephone number that is given with the shipment and request a replacement.

Pour the contents of the shipping container into an aquarium of aged tap water and place the aquarium near a natural or artificial light source.

Classroom care and maintenance. The SCIIS algae ('al-jē) grow best at room temperature (15–25°C, or

Figure L-4. Green algae as seen through a microscope.

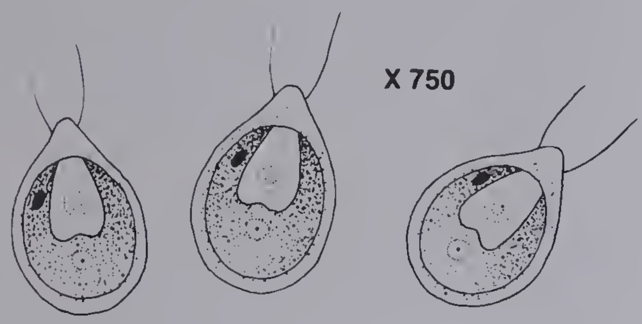
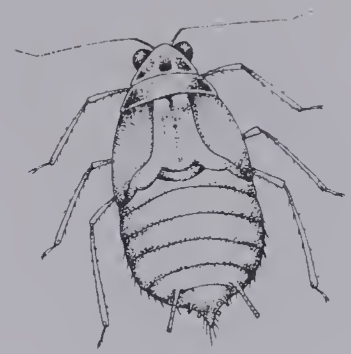


Figure L-5. Aphid.



60–80°F), in aged tap water having a large surface area for absorption of air. Some substances accelerate algal growth. Even without the addition of special minerals, however, algae may grow. For that reason, you should not place an algae aquarium in a strong light unless you are trying to promote overgrowth. You can place it within the lighted area around a SCIIS light source, but not too close to the bulb.

Description and natural history. Like all other green plants, algae have the ability to photosynthesize—to manufacture food from carbon dioxide, minerals, and water, using energy from the sun. But, unlike many other plants, algae do not have roots, stems, leaves, or flowers.

The algae you receive are microscopic; however, a large population in an aquarium will give the water a green color. Other kinds of algae may be seen as dense layers of green filaments floating on the surface of ponds and ditches or attached to rocks in a stream.

The algae used in the SCIIS program live in freshwater ponds and are food for many organisms.

Disposal. Being food for snails and other animals, algae are unlikely to cause any problems of disposal—they will be eaten. If you do wish to dispose of an algae aquarium, first pour the water into a sink drain. Then, with the tap water running, scrape the aquarium walls with a wooden stick, rinse the walls, and discard the rinse water. Wipe the aquarium out with a rag or paper towel.

Aphids.

Receiving the organisms. The aphids (ʹā-fədz) will arrive on a seedling in one or more taped containers. Remove the tape and check the plant for moisture. Add water if necessary. Place the container, without a top, where it will not be disturbed and where the plant will receive some light. Any aphids that have fallen off the plant will climb back on. Check the plant every day and water it if necessary.

If the plant is to be removed for transplanting, use a tweezers or forceps. Carefully lift the plant out and transfer it to soil. Some aphids may fall off during this operation, but they will quickly go back on the plant when put near it.

Plan to transfer the aphids you receive in Shipment EC-2 to the pea plants as soon as possible. If the plants are not above the soil when the shipment arrives, the aphids may be kept in their shipping containers for about one week.

Classroom care and maintenance. Pea aphids require young, healthy plant seedlings on which to feed. Pea seedlings or broad bean seedlings are recommended. Plant new seeds at least once a week, so that there will be a continuing source of food plants. If the new plants are near those with aphids, some aphids will usually move to the new plants. If they do not, transfer a few individuals. Aphids survive best in an environment with high humidity and at a temperature of 20–25°C (68–80°F).

Description and natural history. The pea aphid is a small insect which lives on pea plants as well as on several other plants. Aphid mouthparts fit together to form a needle-like structure which is used to pierce stems or leaves and suck out plant juices. Some aphids have wings, others do not.

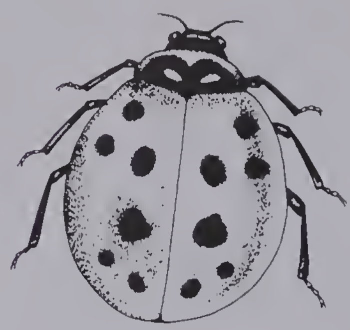
During the spring and summer, usually only female aphids can be found. During these seasons, all adult females can produce eggs that do not require fertilization in order to develop into young aphids. The young develop inside the body of the female and are born live. After emerging from the mother, the young soon attach themselves to a stem or to a leaf and begin feeding.

All newly born aphids are wingless and are quite similar in appearance to adults. They molt at intervals and grow until they become adults. The discarded skins are white and can be seen easily.

Healthy aphids reproduce rapidly on certain species of plants. If a plant becomes overcrowded, aphids may develop wings. The winged aphids usually disperse; if they find another suitable plant they will alight, feed, and produce young.

Disposal. Unwanted aphids can be washed down the drain.

Figure L-6. Lady beetle.



Lady beetles.

Receiving the organisms. Lady beetles will arrive in a plastic bottle with a screw lid. The bottle contains small holes that permit the air to enter the bottle, and so you can keep the bottle closed for several days if necessary.

After the aphids have been distributed to the aquarium-terrarium systems, you may distribute the lady beetles. To do this, have the children remove the lids from their systems. Hold the bottle containing the lady beetles upright over one system and remove the lid. The lady beetles will begin to crawl out of the bottle and walk along the edge of the open mouth of the bottle. Using a pipe cleaner, brush three or four beetles onto a pea plant. Move to another terrarium and repeat the process until all the beetles are distributed. Lids should be placed on the systems immediately after the lady beetles are added.

Classroom care and maintenance. After the lady beetles are added to the pea plants, they should need no special care. However, some of them may begin to crawl through the holes in the container lid. If this happens, cover the holes with plastic wrap.

Description and natural history. The adult is about half a centimeter long; it usually has twelve black spots on reddish wing covers, and has two converging pale stripes on the thorax.

These insects overwinter as adults, often assembling in large groups in the fall before going into hibernation under rocks and forest litter and inside hollow trees. Our commonest and best-known species are voracious feeders on aphids, mealybugs, whiteflies, and scale insects.

The typically spindle-shaped eggs may be attached by one end or in small clusters to the plants upon which the larvae or their prey will feed.

The adults are rather flattened, have a long oval body outline, and have short, slender legs. There are four larval stages. The life cycle from egg to adult takes about three to four weeks.

Disposal. Because lady beetles feed on certain insects, they are considered beneficial. The species lives throughout the country; thus if the weather conditions are suitable the lady beetles may be released outside, or they may be given to another teacher. If neither of the above is suitable, place the beetles in a plastic bag, freeze, and discard.

Guppies.

Receiving the organisms. When the shipment arrives, lower the shipping container into an aquarium in which tap water has been standing for at least two days. After one or two hours, when the contents of the shipping container are at aquarium temperature, pour the contents through a dip net; discard the liquid. The guppies will be caught in the dip net and can be transferred to one or more containers of aged tap water. Be sure to carry out the transfer within a few hours of receiving the guppy shipment. Add several sprigs of hornwort to each container. If guppies are not distributed to the children's aquariums within three or four days, provide daphnias or commercial fish food.

Figure L-7. Guppies.

Classroom care and maintenance. Guppies often eat their young. If you want to increase the size of your guppy population, remove the adults and place them in a separate aquarium.

If a guppy has gray patches on its body or otherwise appears unhealthy, remove it from the aquarium before other fish are infected. Either dispose of the fish or isolate it in a separate container of aged water. If an isolated fish later seems healthy, it can be reintroduced to the aquarium.

Description and natural history. Guppies are small tropical fish. Females are usually grayish in color, while the male is often very colorful. The male is smaller than the female. Also, the male has a spine-like structure on the anal fin (the fin located just in front of the tail, on the animal's underside). This structure is used for tranferring sperm to the female.

Young guppies are born alive. Prior to birth of the young, the abdomen of a pregnant female guppy becomes swollen, and a black spot appears on each side just above the anal fin. Female guppies may produce from six to sixty "baby guppies" (fry) in one brood.

Immature guppies feed on live organisms such as daphnias. However, in the aquarium they can be fed dried fish food. Because the guppy's mouth is on the upper part of the head it can eat food that is floating on the water surface.

Disposal. Give them away if possible. To dispose of unwanted guppies, place them in a plastic bag and freeze, then discard them in the bag.

Design and Use of the Kit

The equipment kit has been designed to help you teach the unit effectively. Except as noted below, all materials needed for a class of thirty-two students have been included. The items are packaged for convenient removal, use, and reuse. In response to feedback from users of SCIS, we have placed a contents list on the front of each drawer. In addition, the chapter "Teaching Materials" lists are now arranged by drawer number.

Familiarize yourself with the entire kit as well as with the diagram and lists on this page. You should inventory the kit before beginning to teach the unit, using the lists on this page for checkoff and notes.

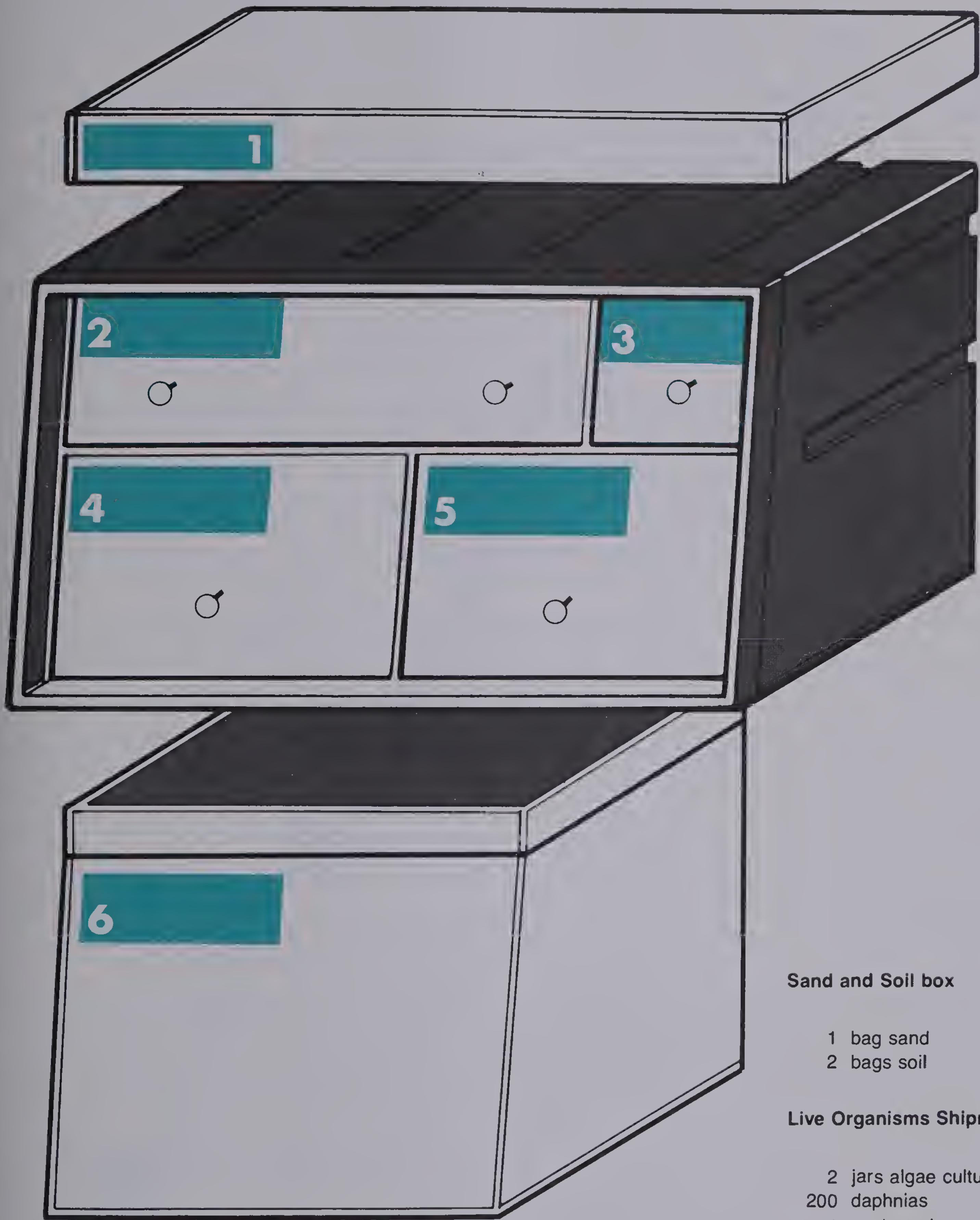
Drawer 1, containing the printed materials, is a separate box. Place it on top of the kit as indicated in the diagram.

Some common items are to be provided by the teacher. The "Teaching Materials" list for each chapter indicates what you are to provide, and the "Getting Ready" notices give you advance warning about these items when necessary.

The live organisms studied in this unit are not included in the kit. Instead, they will be sent separately when your completed order forms are received. Complete directions for ordering are in the "SCIIS Plants and Animals" section.

Drawer	Item Description and Quantity
1	1 Teacher's Guide 32 student manuals 2 sets of Extending Your Experience cards and display box 1 evaluation envelope 2 Ecosystem charts 1 Community label 1 Ecosystem label 1 Environment label 1 Cycles in an Ecosystem label 4 sets Ecosystems photos and Ecosystems data cards 3 North American Ecosystems Maps 1, 2, and 3
2	2 light sources 1 set of Live Organisms Shipments order forms

Drawer	Item Description and Quantity
3	8 medicine droppers 1 rubber stopper 36 seltzer tablets 75 straws 1 sheet adhesive dots, yellow 1 sheet adhesive dots, blue 1 sheet adhesive dots, green 1 roll round labels 12 twistems 12 plastic bags 8 dip nets 1 package pipe cleaners 1 baster 1 package fertilizer pellets
4	8 planter cups 8 planter bases 48 tumblers 1 pitcher 48 vials with caps 4 water sprinklers 8 planter sticks 1 package pea seeds 2 packages clover seeds 2 packages ryegrass seeds
5	8 plastic islands 40 fluted containers 16 tumbler lids 3 bottles bromothymol blue (BTB) 1 bottle vinegar 1 bottle ammonia 16 vial caps with holes 16 plastic tubes 16 thermometers
6	8 six-liter containers 8 six-liter container lids



Sand and Soil box

1 bag sand
2 bags soil

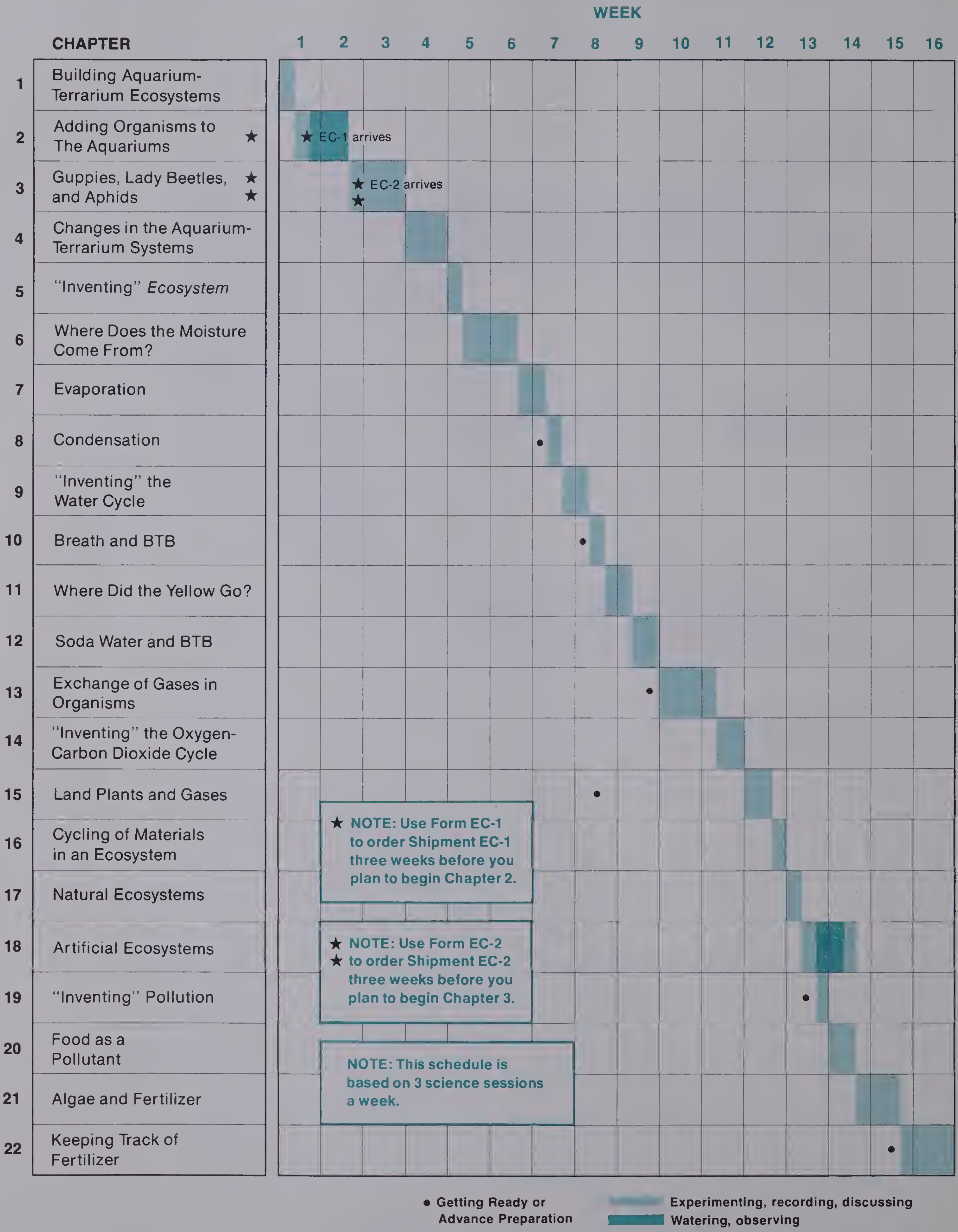
Live Organisms Shipment EC-1

2 jars algae culture
200 daphnias
1 package hornwort
32 pond snails
fish food pellets

Live Organisms Shipment EC-2

100 pea aphids
10 male guppies
22 female guppies
100 lady beetles
200 daphnias

Ecosystems Schedule of Activities



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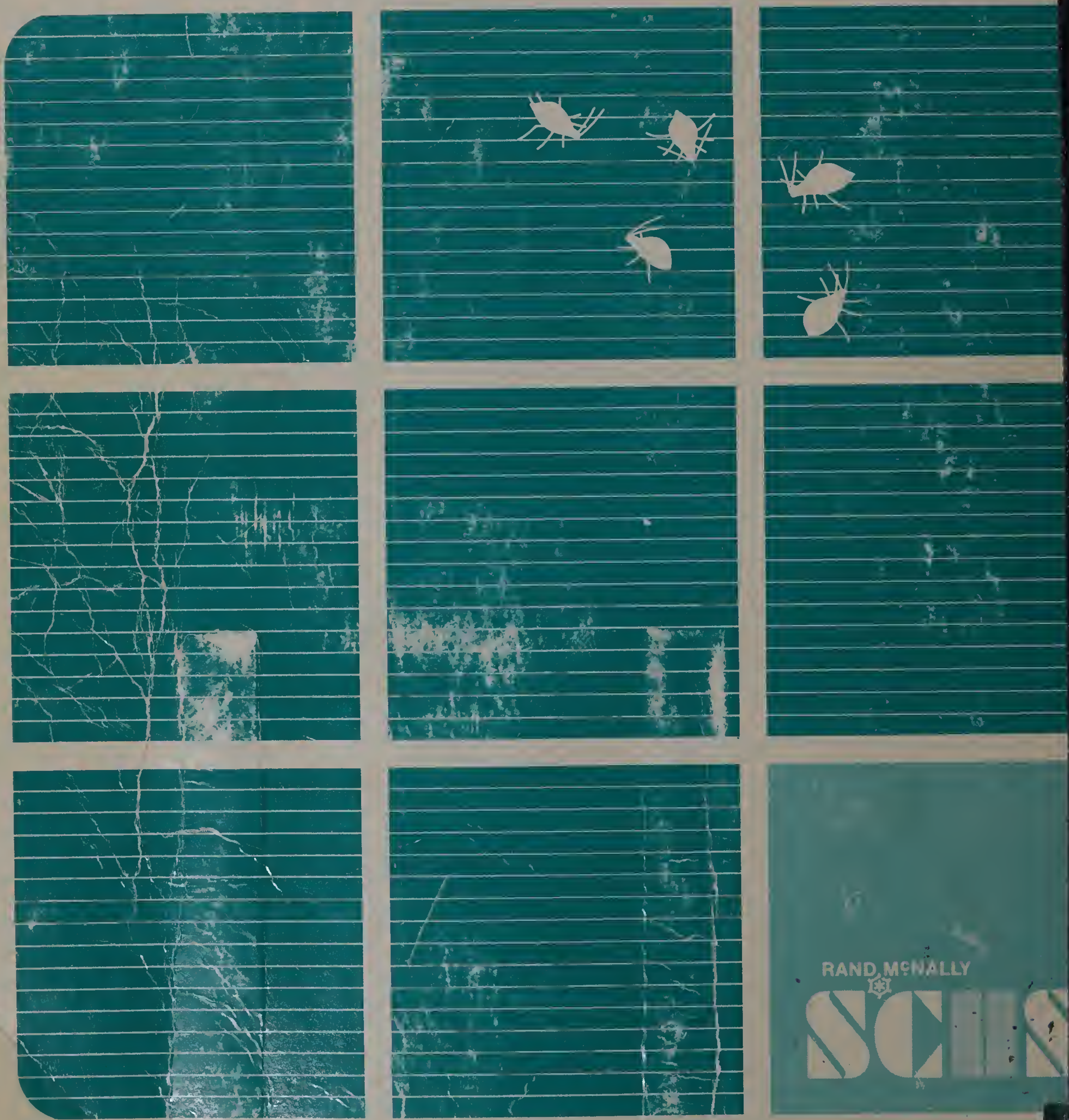

RAND McNALLY

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